DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

NINETY-SEVENTH CONGRESS

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ON THE

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DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

MONDAY, MARCH 15, 1982

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:20 p.m., in room 3110, Dirksen Office Building, Hon. Pete V. Domenici, presiding.

Present: Senators Domenici, Bumpers, and Ford.

Also present: Paul Gilman and Elliot Chakoff, professional staff members; James T. Bruce, counsel for the minority; and Willis Smith, professional staff member for the minority.

OPENING STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator DOMENICI. The hearing will come to order. I apologize for being late. The Budget Committee had to hear from Congressman Royce this morning on a budgetary mandate, and we opened his testimony and got here as quickly as we could.

Today's hearing is being held to review the administration's budget request in the conservation and renewable energy programs for 1983 and the progress of these programs in 1982.

For those who are still recovering from the tough decisions made in 1982 in these programs, it would seem that the 1983 budget would offer little comfort. We are operating under some very tight budget restrictions, and the Energy and Natural Resources Committee has voted to hold spending levels in energy programs at the fiscal year 1982 levels for the coming fiscal year. That represents a 12-percent reduction for energy research and development from what Congress authorized in the Omnibus Reconciliation Act, and a 6-percent reduction in energy conservation research and development.

While the action to this point may be taken as a negative one, there are some very positive aspects. It restates our position that further budget savings are necessary and achievable if we are going to really reduce the deficit. It recognizes that certainty in funding, whether it is level funding or increased funding, is of critical importance in research endeavors. We can't have extreme fluctuation in these kinds of budgets.

Of all the energy research programs in the Federal budget the conservation and renewable energy programs have undergone the most radical redirection in fiscal year 1982. That was appropriate as we removed market barriers in solar and conservation with the decontrol of crude oil and as natural gas further approached market price. There was no need for continued massive Department of Energy commercialization efforts. The role of the Federal Government changed as it properly should. I would add a note of caution here, though. We cannot generalize too broadly about what kinds of research is needed or what kinds of tax credits are appropriate. These decisions must be made in the context of the different technologies and their level of advancement. As the administration has recognized, some research cannot be done by the private sector because of the risk involved or because of restrictions imposed by being a federally regulated industry. In these areas direct Federal assistance in the form of research or indirect assistance in the form of tax credits are justified.

With that, I will yield to Senator Bumpers, and then we will hear from our distinguished witness.

Senator BUMPERS. Mr. Chairman, I do not have an opening statement.

Senator DOMENICI. Secretary Tribble, Assistant Secretary for Conservation and Renewable Energy, we welcome you. Your statement will be made a part of the record, and you may proceed as you see fit.

STATEMENT OF HON. JOSEPH J. TRIBBLE, ASSISTANT SECRETARY, CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. MAXINE SAVITZ, DEPUTY ASSISTANT SECRETARY, CONSERVATION; DR. ROBERT SAN MARTIN, DEPUTY ASSISTANT SECRETARY, RENEWABLE ENERGY; AND JAMES STEARNS, DIRECTOR, OFFICE OF ALCOHOL FUELS

Mr. TRIBBLE. Thank you, Mr. Chairman. I appreciate the opportunity to be here today and discuss the authorization of the Department's conservation and renewable programs.

With me is Dr. Maxine Savitz, Deputy Assistant Secretary for Conservation. Dr. Robert Sanmartin was to be here today, along with Mr. James Stearns. Both of them are having to be absent because of illness, so I will do the best I can to answer your questions and if some of the answers are inadequate, we will give you further information for the record.

I would like to if I may have a brief opening statement that would somewhat set the stage in justifying the budget that we have proposed.

Following the oil embargo of 1973, and until 1980, the United States faced a problem which was quite different from those we had faced in the past. Some thought that our sources of energy were being exhausted. We were becoming more and more dependent upon oil imported from the Middle East. While prices charged for this oil were escalating rapidly, most of the prices for domestically produced oil and natural gas were controlled at very low levels. Relatively inexpensive energy, one of the basic building blocks of our economy, was becoming a thing of the past. Many people felt that this was a problem that the Federal Government could and should resolve, and there was a vocal demand for attempts to do so.

In response, Congress enacted a legislative program which was designed to force energy conservation and subsidize rapid development of energy from renewable sources. Since the enactment of this legislation, billions of dollars have been spent on research, development, demonstration, and commercialization activities for the purpose of bringing into more widespread use energy from such sources as solar, geothermal, wind, biomass, ocean thermal, and alcohol fuels. The technology for using these sources of energy has been advanced to the point where their further development and use can now be implemented by the private sector whenever they become economical.

Today the energy situation does not appear as intractable as it appeared when these legislative programs were enacted. Importation of petroleum into the United States is down more than 50 percent from its previous high. The price for imported petroleum is below its high. The price of domestically produced petroleum has been decontrolled, and the price of domestically produced natural gas has been permitted to rise manyfold over the price at which it was controlled in 1972. Comparing 1972 to 1980, the energy efficiency of the 10 most energy intensive industries in the United States has improved by 17.6 percent. Comparing 1975 to 1981, the miles per gallon of fuel for new domestically produced automobiles has improved by more than 60 percent. Residential energy consumption per household is down almost 20 percent in 1980 compared to 1972. In every case the cost of energy has been responsible for the great majority of the improvements. It is, therefore, entirely appropriate that the role of the Federal Government with respect to energy be reevaluated. Rather than continued emphasis on bringing renewable sources of energy into the market through Federal subsidy, it is now more appropriate for the Federal program to be limited to research of a more basic nature. If some of the remaining unknowns can be removed through research, the private sector will be able to hasten the date when energy from renewable sources will take a more prominent place in our economy.

Much of the money that this committee has authorized in the last few years has gone into hardware. Many of these installations are now in the data collecting stage. It is our intent to gain all the information which is useful from these demonstrations and package that information in the form which will be useful to anyone who wants to use it. Considering that every dollar we spend is a dollar we must borrow at current high rates of interest and add to the Federal deficit, we have proposed a very lean budget.

However, we have tried to continue research which will provide the energy industry with a broader technological base.

Mr. Chairman, this concludes my summary statement. We will be pleased to respond to your questions and those of the other members of the committee.

[The prepared statement of Mr. Tribble follows:]

STATEMENT OF JOSEPH J. TRIBBLE

ASSISTANT SECRETARY

FOR

CONSERVATION AND RENEWABLE ENERGY

U. S. DEPARTMENT OF ENERGY

Mr. Chairman and Members of the Subcommittee:

I appreciate the opportunity to appear before you today to discuss the authorizations for the Department's conservation and renewable programs. The budget before you today reflects this Administration's commitment to the goals of the Economic Recovery Program, the need to minimize Government intervention in the marketplace, and the need to continue Federal support for research in areas where such support is appropriate.

Following the oil embargo of 1973, and until 1980, the notion was widespread that the United States faced a problem which was quite different from those we had faced in the past. Some thought that our sources of energy were being exhausted. We were becoming more and more dependent upon oil imported from the Middle East. While prices charged for this oil were escalating rapidly, most of the prices for domestically-produced oil and natural gas were controlled at very low levels. Relatively inexpensive energy, one of the basic building blocks of our economy, was becoming a thing of the past.

Many people felt that this was a problem that the Federal Government could and should resolve, and there were vocal demands for attempts to do so. In response, Congress enacted a legislative program which was designed to force energy conservation and subsidize rapid development of energy from renewable sources. Since the enactment of this legislation, billions of dollars have been spent on research, development, demonstration, and commercialization activities for the purpose of bringing into more widespread use energy from such sources as solar, geothermal, wind, biomass, ocean thermal and alcohol fuels. The technology for using these sources of energy has been advanced to the point where their further development and use can now be implemented by the private sector whenever they become economical.

Today the energy situation does not appear as intractible as it appeared when these legislative programs were enacted. Importation of petroleum into the United States is down approximately 50 percent from its previous high. The price for imported petroleum is below its high. The price of domestically produced petroleum was even decontrolled and the price of domestically produced natural gas has been permitted to rise many fold over the price at which it was controlled in 1972. Comparing 1972 to 1980, the energy efficiency of the ten most energy-intensive industries in the United States has improved by 17.6 percent. Comparing 1975 to 1981, the miles per gallon of fuel for new domestically-produced automibles has improved by more than 60 percent. Residential energy consumption per household is down almost 20 percent in 1980 compared to 1972. In every case, the cost of energy has been responsible for the great majority of the improvements.

More remarkably, very little of this very great change in circumstance was predicted by those who urged creation of massive Federal Energy programs. In retrospect, we feel that the total effect of all government action has been relatively minor. It is, therefore, entirely appropriate that the role of the Federal Government with respect to energy be re-evaluated.

Rather than continued emphasis on bringing renewable sources of energy into the marketplace through Federal Government subsidy, it is now more appropriate that the Federal program be limited to research of a more basic nature. If some of the remaining unknowns can be removed throuugh research, the private sector will be able to hasten the day when energy from renewable sources will take a more prominent place in our economy.

Let me turn now to the specifics of the FY 1983 budget.

CONSERVATION

In the area of conservation, we will focus on expanding our scientific knowledge base by supporting generic high-risk, long-term research in selected technological areas. This new focus is reflected in the consolidation of our previous sector-oriented programs into a single Energy Conservation Research Program.

The basic objective of this program is to provide the technology base and technology options that the private sector can utilize in the development of more efficient energy conserdvation equipment and utilization processes. This program will solidify the technology base used by the private sector in designing the developing processes and equipment in their application to the transportation, buildings and industrial energy-use sectors.

The FY 1983 request for Energy Conservation Research is $17.5 million, which includes $1.7 million for program direction. This request will fund research activities in four research areas: heat transfer and fluid mechanics, materials and processes, thermochemical conversion, electrochemical storage and conversion. Activities in each element focus on research topics having high potential for improving energy use efficiency.

Heat Transfer and Fluid Mechanics

The request for heat transfer and fluid mechanics is $3.2 million, which will support technology base activities underlying the design of heat exchangers, and fundamental studies of heat loss in structures and industrial equipment. Research will also focus on generic properties of fluids and fluid systems that affect the efficiency of operation of power systems such as advanced heat engines and heat pumps.

In FY 1983, heat exchanger activities will build on earlier efforts that resulted in an integrated, computerized data base and model system for the prediction of flow-induced vibration. Research will focus on the modeling mechanism of flow-induced vibration in shell-and-tube heat exchangers caused by two-phase (steam/water) flow, and on innovative concepts such as suspended particle and direct contact heat exchanger concepts.

Heat transfer research activities directed at structures will focus on wall and roof systems, windows and daylighting, computer modeling enhancements and estimating methods.

In wall and roof systems research, data collected from extensive test cell measurement will be used to analyze the effect of temperature set-back, and windows and doors will be analyzed to determine the effect on building mass. Dynamic performance research will complete analyses of moisture migration and condensation, thermal performance, and air/moisture transfer in wall sections using a calibrated hot box at the National Bureau of Standards.

Research of windows and daylighting will work with physical and computational models to continue development and cross-validation of predictive luminance, thermal, and energy consumption models for analysis of geometrically complex window design, sun control systems, and spaces and for variable filtering devices. Climatological studies will continue to support the effort of luminance availability. In the area of performance, studies on mobile daylighting and thermal test cells will be completed. Validation tests in the field will be initiated on natural illumination, net through-fenestration energy flow measurement, and net room energy-use impact. Estimating methods will focus on the greater common denominator to complete transient heat transfer, fluid flow, and mechanical systems response modeling in the DOE-2 computer simulation program.

Materials and Processes

The major thrust in materials research will be directed toward high temperature structural ceramics. While major advancements have been achieved in shape, fabrication and material strengths of structural ceramics, e.g., advanced gas turbine rotors have been cold spun to 126 percent and 134 percent of design speed with no failure, significant technological advances are needed in order for heat engines to operate more efficiently in severe environments.

Funding of $2.99 million will be directed at advanced materials development and processing, advanced net-shape materials fabricatiopn, and new approaches to assuring structural integrity of advanced materials. Research would also be carried out on evaluation of critical properties of newly developed materials and determination of the interrelationship between newly developed processes, associated microstructure, and properties.

Several projects will be devoted to advanced materials development of: high-temperature ceramic/ceramic composites, ceramic matrix/metal fiber reinforced composites, a new family of transformation-toughened ceramics, and new thermal barrier materials. The goal is to develop composites that are low in cost and have low thermal expansion and conductivity coefficients. These materials will be able to withstand high temperatures, have moderate to high strength, and have high fracture toughness. Property evaluations will be made of friction and wear of ceramics and metals for high load environments. Newly developed ceramics will be subjectd to screening tests, including thermal fatigue to examine their time-temperature-stress behavior. Promising candidate materials (fabricated in realistic shapes) will be tested in realistic environmental exposures.

Other materials research activities will focus on indoor air quality and gas isotope enrichment. In the indoor air quality research, work will be performed on minimum air changes to determine transport phenomena (spatial distribution). The analysis of potential control techniques will be completed. This will build on earlier advancements including development of a simplified device that would allow large scale measurement of air infiltration of buildings to be made at 1-2 percent of the cost of current techniques.

Chemical process research initiated in FY 1982 to study the biocatalyzed production of bulk chemicals, such as nitrogen fertilizer and ethylene feedstock, will be continued. Emphasis will be on techniques to preserve the catalytic activity and increase the lifetime of enzyme catalysts under projected reaction conditions.

Thermochemical Energy Conversion

The objectives of the thermochemical energy conservation are to develop accurate and reliable methods for industry use in designing components for more efficient internal combuustion engines and methods for use in designing more efficient commercial and industrial furnaces. Advances have been made in addressing such technological barriers as our current incomplete understanding of engine and furnance combustion phenomena and lack of technology base. Since 1981, DOE has successfully adopted laser-based instruments to measure phenomena in internal combustion engines and developed computer models to analyze intake, fuel preparation, and exhaust processes in internal combustion engines.

FY 1983 funding of $2.37 million will support improved design and analysis capabilities for operation at reduced fuel-air ratios. Engine cycles to be included are direct-injection stratified charge (DISC) and dilute homogeneous charge (DHC).

In FY 1983, research on high-efficiency energy-conversion equipment/home heating equipment will continue to develop the fundamental understanding of thermodynamic properties, the kinetic properties, and materials/fabrications associated with the coupling of small heat engines to freon compressors. Planned milestones for FY 1982 will result in the development and testing of a dynamic coupling/seal for novel engine freon compressor systems. Successful coupling techniques could lead to industry's development of gas-fired, engine-driven residential heat pumps, capable of operating at double the efficiency of standard electric air/air heat pumps. Work will also be completed on the analysis of novel materials and material designs that could be utilized in the design of heat exchangers for use in residential-sized, condensing-mode heating systems. This work includes analyzing condensation composition of the waste gas stream of conventional heat exchangers.

Electrochemical Storage and Conversion

The objective of the electrochemical storage and conversion activities will be directed at the fundamental understanding of thermodynamics, kinetics, electrocatalysis, mass transport, and materials synthesis and fabrication as they relate to batteries and electrochemical processes and energy conversion. Anticipated milestones for FY 1982 will result in an advanced alternating current propulsion system for an electric vehicle that permits a 50 percent reduction in cost and weight over existing systems. Industry may find many ultimate uses for the results of this research in the development of new technologies such as batteries in automobile propulsion, utility, and residential load leveling.

The FY 1983 request of $7.22 million will fund research on new active and passive cell materials for rechargeable cells offering much higher performances and cycle life at reasonable costs, generic problems of existing rechargeable storage battery systems, and electrochemical conversion systems. We will also investigate the characteristics of existing electrode systems, ionic conductors for batteries with special emphasis on nonaqueous fluid electrodes and characterization of ion selective membranes and separators.

ENERGY STORAGE

A number of projects have been funded under the Energy Storage Program. The Department is requesting approximately $2.2 million under the Energy Conservation Research budget submission to continue basic research on electrochemistry.

RENEWABLE ENERGY

Let me now turn briefly to the renewable programs proposed for FY 1983.

In the early 1970's, the United States began broad-based research and development programs to increase the use of renewable energy. In the early 1970's, there were essentially no privately-funded education or training programs; no manufacturing, installation, operation or maintenance capabilities; no public budget; and little or no overall public knowledge of renewable energy systems. Now, colleges and universities offer renewable energy education courses; industrial laboratories and field testing centers provide training to technicians; and energy consumers have become increasingly aware of the potential benefits of utilizing alternate energy systems to meet their energy needs.

Major changes in the energy marketplace are also providing improved opportunities for renewable energy. The price of petroleum and the scheduled price decontrol of natural gas have effectively removed subsidies from competing fuels; removal of unnecessary regulatory burdens has streamlined siting requirements; and R&D tax credits will stimulate private sector technology development. For a number of renewable energy technologies, the R&D has been essentially completed, and industrial capacity as well as consumer demand has built to the point where the private sector can assume primary responsibility for continued development or commercialization. Specifically, active heating and cooling, passive and hybrid systems, and hydropower can be, and are being, supported by private investments. While further technical investments may be possible, such developments can be left to private industry to pursue in response to market forces. Therefore no specific FY 1983 Federal funding is being requested for these technologies. Similarly, the private sector is expected, over time, to be able to take over electric energy systems and energy storage technology development. Some basic storage work will continue under the Energy Conservation

Research programs described earlier.

For other technologies, the continuation of some Federal Government participation in research is needed to provide the technical base for industry to develop these concepts to a point where potential suppliers and users may begin making their own capital investment. While the strategy to meet this goal has been modified over time to reflect technical progress and the reordering of programmatic priorities, the basic premise for Federal support remains unchanged and serves as the basis for Government activity in FY 1983. With many of the demonstration projects completed and proof-of-concept clearly established for several technologies, the Department proposed to emphasize continuing long-term research while phasing out technology development efforts that can be pursued by the private sector at rates consistent with their economic potential. The FY 1983 renewable energy budget request will be used to support these reseach programs at a level consistent with requirements for orderly scientific advancement.

Photovoltaic Energy Technology

There has been substantial progress in photovoltaic technology and industry development over the past several years in both single-crystal silicon and other, mostly noncrystalline, materials. For single-crystal silicon, the efficiency of commercial cells and arrays has been increased from about 7 to 14 percent, the operational and lifetime reliabilities improved by about ten-fold, and, at the same time, the cost of arrays reduced by a factor of about five. The number of photovoltaic array producers has increased from a few speciality companies, using expensive manual production processes for space applications, to more than 15, many of which use semi-automated pilot production lines to serve the growing market. Industrial sales have increased from a few kilowatts in 1975 to an estimated 5 megawatts of peak capacity in 1981, which amounts to sales of about $75 million. Over this same period, industry has invested substantially in research and development, production facilities and marketing. Industry invested an estimated $100 million for such purposes in 1981. In addition to the component, module and subsystem manufacturers, there are a large number of companies providing information, engineering, design, installation, maintenance and other services to photovoltaic system users and potential users.

For FY 1983, the Department is requesting $27.035 million to continue long-term photovoltaic research that will allow the private sector to address increased efficiency, potential cost reduction and reliability improvements. Experiments will be performed to better understand the cause and effects of defects in silicon crystals. Amorphous materials will be further examined to understand the fundamental electrical and mechaical properties of amorphous substances, to examine the interfaces between dissimilar amorphous materials and to develop better deposition techniques. The physical phenomena in electrochemical deposition processes appropriate to improved thin-film polycrystalline photovoltaic cells will be studied and evaluated. Research will additionally address new materials for very high efficiency multi-band gap cells, fluorescing materials for luminescent concentrating devices, and photoelectrochemical cells. In addition, radically new concepts for ultra-high-efficiency cells will be explored with emphasis on analysis of layer thickness, concentration gradients, and contact metalllurgy.

Supporting research will also be conducted in the area of measurements and predictive techniques. Measurements of the stability of thin-film compounds and amorphous materials will be made, including identification of primary degradation mechanisms. Models to predict output characteristics of concentrator array subsystems, and accelerated life-test models and predictive techniques for silicon modules will be developed and validated.

Solar Thermal Technology

The solar thermal technology program is composed of two major activities. The research and technology development activity involves research on advanced materials and on thermochemical and thermodynamic processes. The systems and test evaluation activity evaluates the technical feasibility of first-of-a-kind solar thermal systems.

Significant advances have been realized in two major concentrating collector types: parabolic trough and central receiver systems. The parabolic trough concentrator efficiency has been improved while simultaneously reducing concentrator structural complexity. For central receivers, advanced heliostate designs and materials which reduced projected costs from those of the first generation designs by 80 percent have been developed. U.S. industry is the world's leader in solar thermal technology.

The FY 1983 budget request is for $18.0 million. Of this, the Department requests $8.525 million for research and technology development to support research stressing thermosciences and materials. Included will be research on optical coating of polymeric materials, methods of minimizing degradation of reflective surfaces due to environmental factors such as ultraviolet effects, analysis of high temperature ceramic receivers and optical windows, high temperature absorbers for thermal storage and the identification and evaluation of solar thermal and photon-driven processes for fuels and chemical conversion.

The request for systems test evaluation is $9.5 million to complete federally supported operation of the 10 MWe Central Receiver Pilot Plant at Barstow, California.

Biomass

A number of biomass technologies are currently competitive in the marketplace. These include direct combustion systems for the production of process steam/heat and electricity or for cogeneration, low-Btu gasification systems, and anerobic digestion systems for the production of medium-Btu gas.

Current biomass feedstock production research activities include investigations of aquatic, woody biomass and herbaceous energy resources. Laboratory investigations are being performed on the production of microalgal oils that can be used for energy applications. Research is also being done on the biochemical mechanisms controlling hydrocarbon production by macroalgal species. Herbaceous energy reseacrh and development, which includes experiments on marginal and arid lands, is being completed in Fiscal Year 1982. In thermochemical conversion, evaluations of a variety of high-performance gasification systems for producing medium-Btu gas and synthesis gas will be concluded in FY 1982 since further development can be left to private industry. Progress is being made toward understanding the basic mechanisms and kinetics affecting the thermochemical processing of biomass through fast pyrolysis and direct liquefaction techniques.

In biochemical conversion, fundamental research is being performed on anaerobic digestion processes. Research activities also include laboratory-scale experiments on photobiological methods for hydrogen production.

The FY 1983 biomass research program will continue to address basic biomass technology research needs. The FY 1983 budget request is for $6.6 million.

Planned feedstock production research activities will focus on the development of microalgal cultivation systems. Basic research in fast pyrolysis, liquefaction, and gasification of biomass feedstocks will continue. Bioconversion program activities will support research that will enable a better understanding of the digestion of crop residues and other low-quality materials. Biochemical conversion research and development will also focus on fundamental research on the microbiology and biochemistry of digestion cultures in addition to genetic manipulation of methane-producing organisms for enhanced yields and efficiencies. Exploratory research in the biological hydrogen program will focus on areas which will contribute to increased hydrogen production efficiencies.

Wind Energy Technology

Both wind energy technology and the industry have progressed substantially in the past few years. There are now some 40 companies involved in the development of small wind systems, compared to seven in the mid-1970's, and about 20 are producing and selling commercial machines. A distribution network is also forming. Approximately 15 intermediate and lage scale wind turbines from about a half FY 1983. With many of the dozen manufacturers are now under construction or in the testing stage, mostly in utility power generation applications. Some of these systems have been developed without direct Federal support. Several utilities have purchased wind turbines for prototype evaluation experiments, and a few private firms are planning windfarms to produce electricity for sale to utilities.

DOE programs to develop advanced small systems are essentially complete. A major thrust of the FY 1982 Wind Program is to complete the predesign phase of the MOD-5 large wind energy system that will have peak power rating in excess of 6 megawatts. The completion of this phase will increase the capability of the private sector to pursue further development of cost competitive wind energy systems for utility applications.

The FY 1983 budget requests $5.4 million for operating funds and $0.1 million for capital equipment. The technical challenge of the FY 1983 program will be to develop methods that will enable machine designers to account more accurately for stresses and fatigue associated with aerodynamic annd structural dynamic loads in wind turbines. Research will be continued on improved analytical techniques and models for predicting aerodynamics, structural dynamics and energy output performance of wind energy systems. Research will also continue on further refinements of atmospheric fluid dynamics models to predict the effects of short-term wind variability and small-scale wind velocity variations on the performance and structural loads on a single turbine and an array. Computer models for generic structural analysis will be validated using test data from existing experimental systems. Material property data for fiberglass/resin and other composites will be developed and test samples will undergo accelerated lifetime testing. Also, the 5-meter and 17-meter experimental Darrieus machines will be operated develop and validate models that predict vertical axis wind turbine performance. Airfoils, and lift augmentation devices with high lift-to-drag ratios,will be investigated. The aerodynamic self-feathering and stall phenomena as applied to movable rotor tips will be studied.

Solar International Program

The SOLERAS Program is a five-year, $100 million, jointly-funded solar energy research and development cooperative agreement between the United States and Saudi Arabia, signed in October 1977. The prime purpose of the Agreement is to advance the state-of-the-art of solar energy. The program covers a diverse set of solar technologies and applications, owing participation by a large group of industrial, academic and research institutions in both countries.

Major accomplishments in FY 1982 include completion of the Solar Cooling Field Test facilities in the southwest U.S. and a photovoltaic village power system in Saudi Arabia. Additionally, work is continuing on solar cooling research, solar-powered desalination, and controlled experimental agricultural systems.

The FY 1983 budget request is for $9.5 million to complete the U.S. bilateral commitment to the Saudi Arabian government for work under SOLERAS.

ALCOHOL FUELS

The Alcohol Fuels Reserach program has focused on the need to develop technologies for producing ethanol and methanol from a variety of feedstocks. As part of this effort, we successfully completed steam explosion tests which reveal that steam explosion is a technically feasible pretreatment process for lignocellulosic materials. During the year we have isolated a yeast strain which produces alcohol at twice the rate of standard commercial yeast strains and another which is capable of withstanding increased ethanol concentrations. We have also isolated an organism capable of fermenting pentose sugars to ethanol, which have significant potential for incrasing the yield of ethanol from ligonocellulosic materials.

We are not requesting any additional funds in FY 1983 for feasibility studies, cooperative agreements or loan guarantees since a total of $271 million is already available for alcohol fuel loan guarantees authorized by the Energy Security Act. Negotiations with 10 compnies for loan guarantees are continuing. These negotiations, if successful, will facilitate the construction of plants with an annual capacity of 350 million gallons of anhydrous ethanol.

The FY 1983 budget request is for $2.9 million. During FY 1983, R&D initiated in earlier years will be brought to an orderly conclusion because this program consists primarly of activities that, over time, can be purused by the private sector in response to market forces. Approximately $0.6 million will be used for methanol R&D, including gasification and catalysis. The remainder will be used for ethanol R&D, focusing on hydrolysis processes for lignocellulosic material. In FY 1983, R&D activities in acid hydrolysis will be completed. In the area of enzymatic hydrolysis we will conclude research to screen and select microorganisms to increase enzyme concentrations and thermal stability and to reduce their sensitivity to alcohol. We will also complete characterization of organisms capable of both hydrolyzing and fermenting either cellulose or hemicellulose to ethanol.

The final area of alcohol R&D includes activities designed to produce fuels from by-product streams. This R&D, including developing technologies to produce butanediol and methylethyl ketone from xylose, will also be phased out during FY 1983.

Geothermal

The three principal types of geothermal resources, in order of their anticipated tecnological readiness, are hydrothermal reservoirs (hot water and steam), hot geopressured brine containing dissolved methane, and hot dry rock.

The DOE R&D activities have significantly reduced the risk involved in finding reliable, safe and environmentally acceptable hydrothermal resources, and reduced the cost uncertainty of their use for production of both electric power and direct heat. Hydrothermal resources have been identified in 37 States; and industry is moving rapidly to exploit them. It is anticipated that the United States hydrothermal electric power capacity will exceed 3,000 megawatts by 1985, and over 200 direct-use development are currently in operation in 16 different States. In FY 1982, we are continuing to support the critical long-term research in enegy conversion, geochemical engineering and materials, and geoscience technology. We are bringing to an orderly conclusion our programs for near-term development in drilling and completion, stimulation and environmental control technology, where commercial capabilities already exist. We are also completing our Geothermal Resource Development Fund activities.

The FY 1983 budget request is for $9.8 million. We plan to continue long-term, high-risk hydrothermal research including continued development of direct-contact binary conversion technology and needed research on the properties of fluids for binary conversion technology and needed research on the properties of fluids for binary systems. In geochemical engineering and materials, we will continue development of high-temperature and corrosion-resistant materials, and technologies for scale control and slurry elimination. We will continue the development and field testing of geoscience technologies to remove technical barriers and broaden the technology base for energy recovery from liquid-dominated reservoirs. We seek to expand our understanding of the physics of reservpors which depend on natural fractures for fluid circulation as well as the optimum technologies for their utilization. A variety of geophysical and geochemical techniques will be used to characterize reservoirs and improve their performance. In addition, we will continue our support of reservoir injection technologies for reservoir management and surface acquifer protection.

In the geopressured program, we plan to complete the testing of four wells designed and drilled especially to evaluate geopressured reservoir performance under production conditions. In the hot dry rock programs, we will complete the experimental work at Fenton Hill, New Nexico.

SUMMARY

As the program levels in the FY 1983 budget reflect, we have initiated a new direction regarding the appropriate Federal role in energy development and conservation, in keeping with the President's golas of economic recovery and reliance on the private sector.

Mr. Chairman, this concludes my formal statement. I would be pleased to respond to any questions.

Senator DOMENICI. Thank you very much, Secretary Tribble. I yield to Senator Bumpers.

Senator BUMPERS. Mr. Secretary, I haven't had a chance to review these figures here on each conservation program, but in your summary statement you said on page 2 that in every instance, the cost of energy has been responsible for the great majority of the improvements. Just prior to that you said comparing 1975 to 1981, the miles per gallon of fuel for new domestically produced automobiles has improved by more than 60 percent.

You weren't here at the time, but I am sure you probably are familiar with the mandate that Congress gave the automobile industry that they achieve certain minimum fleet averages.

Mr. TRIBBLE. Yes, sir.

Senator BUMPERS. No. 1, can you tell me what the national fleet average was last year? For example, in 1973 when the embargo hit, I think the national fleet average of all automobiles on the highways of America was about 12½ miles per gallon. That has been improving progressively since that time. Can you tell me what it was in 1980?

I doubt seriously if you have anything on 1981.

Mr. TRIBBLE. It is my understanding, Dr. Savitz just gave me this number of 15.2 for the fleet average.

Senator BUMPERS. In 1980?

Mr. TRIBBLE. I believe that is 1981, is it not?

Dr. SAVITZ. That is 1980 or 1981, but it is existing fleet and new fleet together. It is both the cars that have been on the road plus the new cars added to it.

Senator BUMPERS. I wanted all automobiles.

Dr. SAVITZ. It is 15.2.

Senator BUMPERS. How many automobiles do you estimate will be on the road at the end of 1981?

Mr. TRIBBLE. We don't have any specific numbers, but my guess would be——

Senator BUMPERS. I believe you do have those numbers, too, do you not?

Dr. SAVITZ. 110 million.

Senator BUMPERS. It's more than that.

Dr. SAVITZ. 120 million.

Senator BUMPERS. It's more than that.

Senator FORD. Keep on going.

Senator BUMPERS. It was 120 million 2 years ago, and we have been increasing it by about 4 to 5 million automobiles a year. I doubt that we have been doing that in the last couple of years.

Dr. SAVITZ. Last year we sold 6 million, but then we retire a certain amount. We can get the exact number for the record.

[The information follows:]

The Federal Highway Administration, Office of Statistics, estimated that the number of cars on the road at the end of 1981 was 124,336,000. The figure will not be finalized until approximately July 1, 1982, but the annual estimate has always proven to be within 3 percent of the correct, calculated figure.

Senator BUMPERS. Between 120 and 130 million automobiles; be that as it may, the average you are giving is 15 something, is all automobiles?

Dr. SAVITZ. Yes.

Senator **Bumpers**. Now what is the mandated national fleet average that is required of the automobile industry for 1981?

Mr. **Tribble**. Senator, is that for the fleet average or for the new?

Senator **Bumpers**. New automobiles; I think it is 21 miles per gallon.

Dr. **Savitz**. Maybe 23 for 1982.

Senator **Bumpers**. No. It is 22. I don't know why I am asking you questions I know the answer to.

Dr. **Savitz**. At the end of 1985 it is 27½.

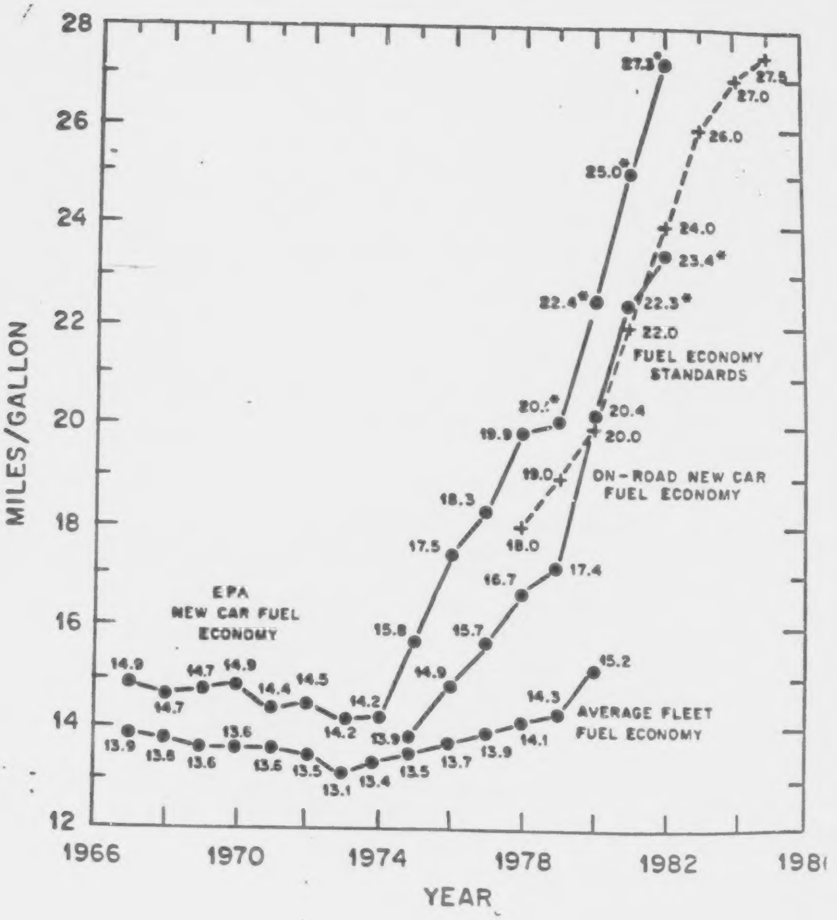
Senator **Bumpers**. Really what I am driving at is this. The Secretary's statement is that in every instance the response has been because of price. I rather doubt that, Mr. Secretary. I think price has been a factor, of course, but I also think that the mandate that the Congress put on the automobile industry in 1975 has been very significant, has had a very significant effect on what Detroit might have otherwise done had it not been for that mandate.

Mr. **Tribble**. Senator, we have recent numbers on all of these, and I have it in graph form. We will be pleased to make it available for you.

Senator **Bumpers**. Is this the graph you have?

Mr. **Tribble**. No, that is not, the graph is provided.

[The graph follows:]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MILES/GALLON
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Senator **Bumpers**. Well, let me ask you on a second subject now, completely away from automobiles, all these programs here—energy conservation, we have building and community systems, industrial, transportation, State and local, weatherization, assistance grants, energy policy and conservation grants, Energy Extension Service, and program direction—now program direction, you have asked for $4,260,000 in 1983.

Is that just to shut all conservation programs down with? Is that the administrative expense of shutting down conservation?

Mr. **Tribble**. We are really not shutting down conservation. We are going forward. We are, as a matter of fact, rearranging the conservation program, and instead of having research and development go forward toward end uses, it is going to be a more generic research.

Senator **Bumpers**. Well, the total amount requested by the administration is $21,802,000 from the 1982 base of $383 million. One of the concerns I have is how are you going to carry forward the programs that are in existence right now, research that is going on right now? How do you propose to get any benefit out of those if we just sort of stop in midstream? Surely some of those offer some benefits to the people of the country.

Mr. **Tribble**. In all of the programs where we would propose to either reduce or terminate the activity, we would expect to carry them forward to an appropriate milestone, and to make the information that is gathered available to whomever might use it.

One of the examples that I might use is the work on the Sterling engine. The Sterling engine has progressed to the point where you can if you want buy a Sterling engine, but we feel that we have gone far enough with it after 1982. This engine then will be tested on a dynamometer, and it is an available system.

We would think that we need not go forward with that anymore. The same thing is true with the gas turbine work for automobile use. By the end of 1982, we will have a complete engine. Of course, it will be made of all metal parts. It will be tested on a dynamometer at the end of 1982. Further improvements in the efficiency of that unit will depend upon the substitution of ceramic portions for the metal portions so that we can go on up into higher temperature ranges. We would propose to go forward with research and development on the ceramic components, but not to integrate them into the machine. We would hope that inasmuch as this is a cost shared project, that we would be able to get the industries who are working with us on this as their part of the project, test the components in the engines. So it is with many of the programs that we have. In many we are reaching an appropriate point where we feel that research is changing or that certainly the building of hardware is not necessary.

Senator **Bumpers**. On these weatherization assistance grants, do you have any data that this committee could use as to how effective that program has been and how much we have saved per dollars spent, how much energy we have saved per dollar spent?

Mr. **Tribble**. We do have those numbers, yes, sir. We would be pleased to submit them.

[The information follows:]

Under the DOE program over 800,000 homes have been weatherized, $565 million expended through December 31, 1981, resulting in energy savings of 3.2 million barrels of oil equivalent (BOE) per year. Each dollar spent under the program saves .84 BOE. This estimate assumes a 15-year life for the energy conservation measures installed. The cost per barrel of energy saved is $11.77.

Senator BUMPERS. You do not have them with you?

Mr. TRIBBLE. My recollection is that the money spent has been on the basis of about a 3-year payoff. We have weatherized some 800,000 homes. The result of that has been quite good.

Senator BUMPERS. You personally favor continuation of that program, Mr. Secretary?

Mr. TRIBBLE. Certainly we have to consider the plight of the low-income people in the Nation, and this is one way that has been used to assist.

However, there are millions of homes that, according to the criteria that are established by law, meet the economic criteria for weatherization, on the order of 12 million. To date, we have done 800,000. We are really just scratching the surface of the problem.

We do feel that this is an issue that is more capable of being addressed by the Department of HHS and HUD because they are more familiar with the operation of this kind of program. While weatherization does save energy, we look at the weatherization program as fitting more properly in that category.

Senator BUMPERS. Just as an aside on that point, the people in my State, and of course we are almost totally dependent on natural gas for heating—the people in the Northeast who are especially more dependent on heating oil are getting a pretty good break now. I saw where heating oil was 75 cents a gallon in New England. Certainly that is a break, and I am very pleased that some of those people are getting that break. Unhappily, in my State the trend is in the other direction because we are dependent on natural gas, and one of the common laments that I hear from my people is that we have spent so much money weatherizing; we have put in double-paned windows, storm windows, and we have put in weather stripping, and we have insulated, and we have done all these things, and yet our heating bill is still 50 percent higher than it was last winter.

Of course, that is for two reasons. The winter was a lot harsher this year, but it is mostly because of the increased price of natural gas. If rising heating bills are discouraging the people who have done those things to weatherize their homes and who get tax credits for having done it, you can imagine how devastating this is to people who really are genuinely poor, and particularly the fellows who are dependent on social security and that sort of thing, and that is one of the reasons I have been a strong, staunch supporter of the weatherization program.

I paid a $70 gas bill at my house in Arkansas from January 4 through February 4, and I think my wife and son were there one weekend, and the same bill here was I think $210. Now you just have to wonder what the poor folks are doing, and to torpedo this weatherization program I think is not only tragic from their standpoint, but I also think it is tragic from a national conservation standpoint.

I think that we are lapsing back. Automobile dealers tell me that they are beginning to sell the midsized and the large cars again, and I really consider that a tragedy because, if Saudi Arabia chose to tomorrow, they could end the world glut tomorrow if they wanted to and prices would start right back up and we would be back where we started from.

Are you familiar with the GAO report that says we are no better able to cope with an embargo right now than we were in 1973?

Mr. TRIBBLE. No; I'm sorry, we are not.

Senator BUMPERS. That is a tragedy of Congress and two administrations as far as I am concerned, three administrations, but I would have to say that I think it is more an act of Congress than it is of any of the administrations within the White House since I have been here, but let me ask you one other thing. How about the building standards that we started off so nobly with a few years ago? Is that just dead? Is the concept of national building standards for residences and commercial buildings, is that dead?

Mr. TRIBBLE. This is in Dr. Savitz area, and if I may, I would like to have her respond to that.

Dr. SAVITZ. I think the idea of a federally mandated standard, in fact, Congress last year changed the law to make it a voluntary standard, and over 40 States have implemented some sort of a building standard, and usually use the ASHRAE standard, the one by the professional society.

What we are doing this year with money that was appropriated in fiscal year 1982 is to finish up the technical work that we had done related to the building standards, looked at what kind of standards you might have for different types of residential homes in different climates, what kind of cost effective measures make sense for mobile homes, put this information in technical documents that then the building industry can use in their actual practice of building. We think that is much better than having to go through a whole regulatory type of procedure, and then to give them the tools they needed. That type of information will be very useful to them.

We will work with the homebuilders and with the architects and with ASHRAE in putting it in the right format. A lot of research has been sponsored as a result of funding by the Congress.

Senator BUMPERS. My time is up, Mr. Chairman.

Senator DOMENICI. Senator Ford?

Senator FORD. Thank you, Mr. Chairman. Two or three questions, Mr. Secretary—on your first page you say relatively inexpensive energy is one of the basic building blocks of our economy. On page 2, you seem to be very pleased that importation of petroleum into the United States is down approximately 50 percent from its previous high. Well, it has been declining since its previous high all along as I recall, but Senator Bumpers just made a statement which you agreed with that OPEC could eliminate the international glut on the oil market any time they want to turn it off. That is one problem, and two, if and when we get back to full production, say of 95 percent, how much oil then will we need to import since we are down, I believe the latest figure is about 68, 69 percent of full production?

How do we handle that 20 to 25 percent increase of industrial production with the energy imports?

Mr. TRIBBLE. There is no question that when the economy improves and business activity increases, that demand for petroleum will increase, and quite likely importation will again increase.

However, the conservation measures that have been taken in industry and in transportation and buildings will continue to be effective even though economic activity does improve. The work that has been done in industry to cut down on the energy use has been reported in terms of per unit of productions so that we would expect actually when these industries do return to a fuller utilization of their facilities that they will continue this improvement.

One other factor in that is that when the energy shortage first came upon us in industry the things that could be done quickly and with little cost were done immediately such as insulation, closing up leaky steam lines and things of that nature, and the things that remained to be done to further improve energy utilization efficiency per unit of production are going to be the result of capital expenditures.

The tax bill that you folks passed last year will provide quite an incentive for industry to install energy-efficient equipment, and it would occur to me that as the activity increases, we will not see the return to the circumstances that we did have earlier in the decade of the seventies.

Senator FORD. As it relates to the tax program, what is the acceleration of purchases for energy-efficient new equipment? How have they accelerated since we passed the tax bill?

Mr. TRIBBLE. It has been too short a period of time for us to have any data on that.

Senator FORD. I thought you would at least get a feel of how well it is doing.

Mr. TRIBBLE. I think those things will have to be—I'm sure you realize that the path from conception through the corporate board of directors does take some time before these additional facilities can be authorized, and then, of course, it takes several years in many instances to get them installed.

Senator FORD. Did I understand you to say in answering Senator Bumpers, one of his questions, that you basically were compiling the information and it would be available to anyone who wanted to use it?

Mr. TRIBBLE. That's right, on all of the programs that we are, where we have had hardware that we are in the process of getting data from, we expect to put this data in a form that will be useful to anyone who wants to use it.

Senator FORD. Much of the conservation research that you have cut relates to the building sector and the automotive industry.

Do you expect these two sectors which are in a state of absolute depression to fund this research?

Mr. TRIBBLE. In some instances, they will.

Senator FORD. What instances?

Mr. TRIBBLE. In the building industry they are going to be hard pressed because it is a diverse business. However, we have been working with the Electric Power Research Institute and the Gas Research Institute to pick up some of the programs that we have ongoing, and we are continuing to do research in the building sector.

One of the things that we have found when we reduced infiltration is that we get some buildup of impurities in the air, and we are going to continue to work in that direction to determine how many air changes have to be for health reasons, and we also are working on heat exchanges so that the air can be properly exhausted and be used to heat the air that is coming in.

We have been working with such organizations as the American Institute of Architects and ASHRAE to get the information that we do have into the hands of those people who will be able to implement the things that we have learned.

Senator FORD. Mr. Secretary, has the Department conducted any kind of studies or analysis which would justify your position then that the private sector will conduct the research you are cutting?

Mr. TRIBBLE. No, we haven't conducted any such studies.

Senator FORD. So you really don't know, whether the private sector will pick it up or not? You are just hoping?

Mr. TRIBBLE. We think that they will pick it up where in their judgment it is economically the thing for them to do.

Senator FORD. Well, you really don't know. You really don't know, any leadership that the Government should give here is going to be null and void from now on in the future, whatever you have been able to compile, whatever data you have, will be turned over to any individual or group that might want to use it, and if they want to continue, that's fine. If they don't, why whatever has been done, that is the total sum of it?

Mr. TRIBBLE. Well, I wouldn't say that that is the total sum of it.

Senator FORD. I am just looking at your figure, the 415—let's see. I don't believe I have it here. I am looking at personnel instead. Anyhow, it is just almost devastated.

Mr. TRIBBLE. If we consider it costs us $100,000 a year to keep 1 person employed in research, we will be able to keep some 175 people involved with research on conservation with that budget. Of course, not all of that budget will be going in that ratio.

Senator FORD. You are not going to have that many people in that area?

Mr. TRIBBLE. Yes. I'm sorry.

Senator FORD. You will not be keeping that total number of employees based on those dollars you just related in that one area?

Mr. TRIBBLE. Yes. Yes; we will.

Senator FORD. You will?

Mr. TRIBBLE. Yes.

Senator FORD. Well, let me just ask you this then. What if Congress gives you as much funds or budget, as much in 1983 as it did in 1982? How are you equipped to handle it?

Mr. TRIBBLE. We would, of course, propose that you not do so.

Senator FORD. What if we do?

Mr. TRIBBLE. If you do, we have not made any plans to use that order of magnitude of dollars.

Senator FORD. Well, what if we do? You just have no plans?

Mr. TRIBBLE. We would certainly take a real hard look at the things then that we feel that we can get some benefits from and direct that money into that area.

However, I would like to point out that much of the money as I said a few minutes ago has gone into hardware. Many of these hardware installations are being terminated, finished. We are not shutting them down. We are getting the information that we set out to get, and there will be no reason to go back and continue some of those activities. We would simply be spending money over on the same kind of thing such as the repowering design in solar thermal. The wind program where we are spending money now, we will reach a point where we feel our work in that field should be terminated.

Senator FORD. Would you give me your definition of energy conservation?

Mr. TRIBBLE. Efficient utilization.

Senator FORD. I'm sorry?

Mr. TRIBBLE. More efficient utilization of energy.

Senator FORD. Do you include in more efficient utilization doing without energy?

Mr. TRIBBLE. No; I do not. I do not consider that conservation means doing without. To me, conservation means finding a way to use energy more efficiently.

Senator FORD. You don't believe in reduced use?

Mr. TRIBBLE. Well, I think that a large portion of the so-called conservation or let's say the reduction in energy consumption that we have seen has been the result of doing without many things. For example, a lot of us used to run our houses at 72° and wear light clothes. Now we can get away with it at 66° and wear something heavier. We don't drive quite as fast. We don't travel quite as far. A lot of those things certainly have had their impact, and I think that they will be continued as a result of the price that energy now costs, but I don't know that those have been so severe as to cause great dislocations in the standard of living.

Senator FORD. I believe my time is up. I still have a few questions. A lot of conservation resulted from buildings and cars and making steel and manufacturing the hardware abroad, and a loss of jobs at home to produce energy conservation. It is pretty heavy.

Thank you, Mr. Chairman.

Senator DOMENICI. Mr. Secretary, I have one question that I was asked to propound to you by Senator Weicker. It has as its genesis that we haven't come up with the appropriated level of funding for 1983. While you have a budget, we haven't completed work on it. His question is do you intend to issue any additional RIF's for Congress before it completes its work on the 1983 budget? Do you know the answer to that question?

Mr. TRIBBLE. We do not now have any plans for any RIF's.

Senator DOMENICI. Thank you, Mr. Secretary. You are redirecting much of your effort in solar and conservation, and that effort obviously is going to result in the availability of a number of very excellent and expensive facilities. It is going to require that they find what we might call a new home or we are going to have to mothball them.

They are really demonstration and research facilities. I will quickly tick off a list of them here in a minute, but it does seem to me that this ought to be a very urgent item for you. It is right within your jurisdiction.

Are you presently discussing new homes for these kinds of facilities, either all of them or part of them with either a true private sector institution or some kind of a consortium? Let me just give you some examples—Atlanta, Ga., the Georgia Institute of Technology's Advanced Components Test Facility; the Sandia Lab's Central Receiver Test Facility; the Edwards Air Force Base Jet Propulsion Parabolic Dish Test Site; the State Land Grant College in New Mexico's Physical Science Solar Furnace. I think there are four or five more.

Now, Mr. Secretary, it appears to me that you ought to have some plans as to what we are going to do with those facilities. There is developing a group of organizations who are worried about how we are going to handle them. They call themselves a user association group.

Now before you answer the question, Mr. Secretary, I want to say to you from this Senator's standpoint, I think it would be disastrous, No. 1, if you do not have adequate authority to affect a transfer either on an interim or permanent basis, to that kind of user or private sector group. That should not be an excuse. We want you to tell us if you don't have the authority because obviously we want to give you that authority.

Second, I personally think that it is going to be disastrous if you aren't moving with all the expertise around in that direction even if you only have limited use over the next decade. It would seem to me that at the minimum we might be willing to put some seed money into a nonprofit entity that might coordinate the end user activity for all of them. We are talking about hundreds of millions of dollars in hardware, just the ones I have spoken of, and I left four or five of them off. A couple of them are international. There is one involved in France that if we look at the budget, they are closed down at the end of the year.

Could you address that subject, please?

Mr. TRIBBLE. In the case of the best facility, we have been working with the Electric Power Research Institute and their utility for the testing of batteries. We have worked out an arrangement where the utility and EPRI will carry on that activity. We are backing away from it. They have agreed to go ahead. Certainly some of those facilities that you mentioned are now being used. For example, the Central Receiver Test Facility at Sandia and the Rocky Flats Wind Test Area in Rocky Flats are being used by the private sector to some degree to bring in their concepts of those technologies and test them, and we are making efforts to transfer this more adequately to the private sector in that fashion.

We realize that these are Government installations and we should not dispose of them, but what we want to try to do is to have their operation financed through activities of the private sector, bringing equipment in, having it tested. In some of the instances such as the ones at Georgia Tech, the Shenandoah project, for example, we have been working with the utility involved which is Georgia Power Co., and we expect that we will be able to work out a satisfactory arrangement whereby they will take over that facility.

To answer your question, yes, we are working with a number of organizations to move this, these facilities, into that kind of use. In the instances of the hardware that I have spoken of, for example, the Barstow facility, central receiver facility, we expect to be able to transfer it over to the utility—not transfer it, but actually work out an arrangement whereby we will get the benefit that we have been looking for, and if it is economical, they will be able to continue to operate, so we are working in that direction.

Senator DOMENICI. Was the last one contemplated to be handled as you are saying.

Mr. TRIBBLE. Yes. That's right.

Senator DOMENICI. A number of others were not. They are purely demonstration and research. Now I want to state once more for you how I feel. I don't argue with you on any of the direct transfers, Georgia or the like.

It would appear to me, however, that there are a number of facilities that have broader research usability than as direct as a utility in Georgia being related to it. We have some very exciting scientific programs in our country where our Nation builds it and then the great scientists try to use it. The one I am most familiar with is the very large array which you may or may not know about over on the Sacramento plain in New Mexico which now makes America the lead in looking out into outer space the regular way. The peer group says which scientist ought to use it to do his experiments.

It appears to me that you ought to be looking at things that we want to get out of and where they have that kind of capacity, we ought not be mothballing them. I am one who doesn't want to spend money, but it appears to me we have some models around that would indicate that with a little operational money for an entity, the scientists could make use of it. Sandia could tell us up front they have done their work on the central receiver, but they would not say there aren't others who would not want to run experiments.

We understand it will be closed, phased out by the end of the year, but we certainly don't want you coming here saying we have not thought through with experts how they might utilize it, and instead of millions per year, with a couple hundred thousand we keep a number of them alive. I merely suggest that as a kind of a notion. I hope you are doing that, and I would ask you with reference to those kind of facilities that are valuable, that you would report to us as soon as possible as to your success in getting some continued use for them either in the market as Barstow is or for research users.

Would you do that for the committee?

Mr. TRIBBLE. We would be pleased to. An example of our approach is our combustion test facility that we have. We, of course, are going to continue to do some work in this area, but at the same time, we are trying to get the industry that can and does use it to come in so that they will be able to take over part of the financing of the operation.

[The information follows:]

I have recently commissioned a task force to assist me in identifying facilities for transfer to the private sector. Over the next several weeks, we will be assessing which facilities can be transferred to industry or the university research community and how those facilities might best be used to produce the benefits we and the private sector feel are essential. At the same time, alternatives for disposal will be devised for any facilities having functions that offer no further benefit to us. This task force will then ensure that specific plans for transferring or closing down these facilities are devised and implemented.

Senator DOMENICI. You mean the Sterling engine?

Mr. TRIBBLE. No. I was thinking about the combustion work that is being done at Sandia, at Livermore I believe on the laser spectroscopy work. It is being picked up by the automotive engine companies, and they are benefiting from the work that we have done. They are helping us continue the operation of that facility.

Senator DOMENICI. Senator Bumpers, do you have a question? I have a few more, but you wanted to ask something?

Senator BUMPERS. That's okay.

Senator DOMENICI. Let me ask you about the administration's recommendation that we do away with the energy tax credits. I don't expect you to be an expert on what the Treasury recommends, and I don't ask this question to embarrass you or anything. It just seems to me as a committee member here that we ought to know.

Did we have Treasury working with you all or did they decide that they were going to recommend getting rid of the energy tax credit simultaneously with a budget recommendation that we have no more money to do the work?

It appears to me that if they didn't coordinate it, then you have got but one conclusion, and that is there will continue to be an investment, for instance, in photovoltaic cell activity with very little money in your budget, and no tax credits left. That doesn't seem to me, from what I have learned in that area and in solar, to be moving in a coordinated way.

Do you understand my question?

Mr. TRIBBLE. I believe I do.

Senator DOMENICI. Tell us about it.

Mr. TRIBBLE. We did not collaborate with the Department of the Treasury in eliminating the tax credits insofar as I know, but when you look at the effect of the 1981 tax bill, then the elimination of the tax credits, the additional 10 percent investment tax credit for energy property, makes a great deal more sense because if you run out the economics of accelerated depreciation versus the additional 10 percent investment tax credit, the two are not so far away, so that what I am saying is that while the investment tax credit was removed, the fact that the accelerated depreciation is available is, more or less evens that influence.

One other point, and that is the provision in the 1981 tax bill which does in fact encourage research and development is another factor, so while we did not participate in that decision insofar as I know, the 1981 tax bill does to a large degree offset the effect of removing the additional investment tax credit.

Senator BUMPERS. Mr. Chairman, so we don't have to pursue it--were you going to pursue this question?

Senator DOMENICI. I was going to ask him one further question. Mr. Secretary, with reference to photovoltaics, it is not a very big industry yet. Competition is tremendous. We are still out in front of Japan. This is one of those activities that the United States has an opportunity to be involved in with the underdeveloped countries. That is where most of the photovoltaic use is going to be, as you well know.

The problem that the industry tells this Senator is the opposite of what you have said, and I would hope that you would meet with them and ask them. They indicate that general business depreciation will not work. As a matter of fact, it is generally accepted that if you wipe out the photovoltaic tax credit—worse than that, if you don't increase it slightly, we will not have sufficient domestic base to remain competitive in the world market. Without the base here pushing it, the general consensus is that Japan will overtake us very quickly.

I don't expect you to believe them as stated to me, but I would only urge that you ask, because it is such a small amount of money that I can tell you I will certainly propose that it be exempt from any reduction in the credit, and just a small increase can be shown to keep the industry alive here. We can sell that product in the world, but it seems to me the reverse is exactly what is going to happen, and this has some very excellent potential for us because the users are those that don't have central power systems. They are underdeveloped. The more we can have our people go out there and do it even though it is paid for, be it the International Bank or whoever is paying for it, the better off we are, and I would just ask you if you would meet with them because I think the arithmetic is very simple. I think they could convince you, and then if the Secretary permits, I would very much after you have done that appreciate your reporting to this committee as to what you have found.

Mr. TRIBBLE. We are very pleased to do that. Certainly there are exceptions to the general statement that I made earlier about the offsetting influences of the taxes. The photovoltaic industry is doing quite well, on the whole. We have some information that you may not have. In 1981, sales of photovoltaic arrays were estimated at $75 million, which was a 50 percent increase over 1980. There is a company, Solarex, that plans to build a 6 megawatt photovoltaic plant to start in September of this year. A number of the companies in this business have made substantial investments and certainly they are in the forefront of this field. We will be pleased to get that, work with them, and report back to you.

[The information follows:]

The Department's Photovoltaic Energy Technology Division staff and various field program managers have continuing contacts with the U.S. photovoltaics industry. An assessment of these contacts indicates that industrial opinions are mixed in their preception of the value of the 15 percent business energy tax credit for renewable energy technologies relative to the R&D tax credits and the accelerated depreciation schedule for equipment investments. Many company representatives feel that the special business tax credit for energy investments are needed for more rapid growth and market development while other company representatives feel the recent R&D and accelerated depreciation incentives are a reasonable alternative to the business tax credit. Overall, it appears that the photovoltaic industry sales have not relied heavily upon the business energy tax credit and that the industry should continue to grow even without such credits.

Senator DOMENICI. Thank you, Mr. Secretary. Senator Bumpers?

Senator BUMPERS. Mr. Chairman, I just want to say that I couldn't support your position any stronger on this whole question of photovoltaics. It is a place where we have a competitive advantage. We ought not to lose it. It is obviously going to become one of the biggest export technologies in a very short time.

I don't know what the per watt cost of photovoltaics is right now. It was close to $15 a watt when I came to the Senate, and my guess would be it is probably down to $3 or less right now.

Mr. **Tribble**. I wish I could say that were true.

Senator **Bumpers**. How much is it now?

Mr. **Tribble**. It is $7.50.

Senator **Bumpers**. That's just like meat frying. You can hear everything.

Senator **Domenici**. That's about right.

Senator **Ford**. It's a pretty good decrease.

Senator **Bumpers**. It is a dramatic decrease, but I understood that the Mississippi County Community College in my State, which is the first all solar cooled and heated college in the country, that the cost of that plant was down to almost $3 a watt, so obviously that is not true.

Senator **Domenici**. But Senator Bumpers, the figure he gave is not so bad when you look at isolated energy generated in one of the underdeveloped countries, so we are not comparing apples and apples. It is really apples and oranges. The problem is they have to have a boost here to get some of it going, and that is being done here by the tax credit. I don't think there is anyone who will deny that. If he meets with the company, they will tell him they are building something new, but they are pretty worried that that may be the end of what they do if this tax credit is wiped out.

Senator **Bumpers**. In that connection, Mr. Secretary, how about Solarex? You mentioned them. Are they operating on any kind of Federal grant?

Mr. **Tribble**. Yes. We have been working in a cooperative development with them over a period of years which if I remember correctly is an amount on the order of $9 million, and they are doing very well. I was out and visited their plant just recently.

Senator **Bumpers**. Where is it?

Mr. **Tribble**. It is here in Washington, Rockville. They are in production. They are obviously selling their product. They are building another plant.

Senator **Bumpers**. Do you believe they will be as aggressive as they have been without some additional incentives from the Government?

Mr. **Tribble**. There is no question that any tax credit, any additional incentive, will help.

Senator **Bumpers**. They are operating on more than just tax credits. They are operating on actual grants.

Mr. **Tribble**. No. They do not have any grant from us, as far as I know. I think this is a cooperative effort.

Senator **Bumpers**. You say it is a cooperative effort. You are talking about technology furnished by the Government, are you not, to assist them?

Mr. **Tribble**. It is a joint effort. That's right.

Senator **Bumpers**. We are putting up half the money or some amount. I understand under this proposed budget that would come to an end.

Mr. **Tribble**. Yes.

Senator **Bumpers**. I think that's tragic. They would still, of course, have tax credits, and I know, as Senator Domenici has already said, that that is not in your ballpark, but I would like to point out one thing to you, that in 1980 we gave the oil and gas industry $5.75 billion in tax subsidies for two items in intangible drilling costs and percentage depletion allowance, and in that same year, we gave $1.66 billion in tax credits for people who did all kinds of conservation, made all kinds of conservation investments.

Now what we gave the oil industry comes to well over $1 per Mcf, or a 1,000-Btu equivalent, and in my opinion, if we gave anything like that amount in conservation tax credits we would probably get two to three times as much benefit so far as the use of oil in this country is concerned, so I am just simply saying that. That is a belief, and I think I can back it up. I didn't come prepared to debate this item today, but I am going to try to get my statistics on it together.

Mr. **Tribble**. May I respond to that?

Senator **Bumpers**. Certainly.

Mr. **Tribble**. We do have a request for $27 million in our budget for photovoltaics, and we are doing research that we feel will be very helpful to the industry. For example, we don't feel that we, any of us, know enough about the photon conversion process, and we want to go more deeply and more basically into that so that the companies will be able to know more of the basic information.

We are reducing our expenditures primarily in those areas where we have been helping them reduce cost, but we are trying to go ahead with research that will be beneficial to them so that they can improve efficiency of conversion, reduce module cost and things of this nature. We are planning to spend this money in the direction that will assist industry.

Senator **Domenici**. Will you yield, Senator? Mr. Secretary, I wonder on that question about the $27 million, I understand you want to get out of that part of the photovoltaics that puts us in the pushing-the-market acquisition?

Mr. **Tribble**. That's right.

Senator **Domenici**. That is what you are dropping. I wonder if you know how much Japan is going to spend in direct R&D for photovoltaics generic research? My understanding is it is more than the $27 million. I wonder if you would dig that up for us and submit it along with the other information, and with some explanation. It is not necessarily overly relevant, but perhaps we ought to know about it.

Mr. **Tribble**. I will provide it.

[The information follows:]

Based upon recent informal information exchanges between United States and Japanese photovoltaic program representatives, the Japanese Government's photovoltaic budget for the period which extends from April 1982 through March 1983 is about $29 million for materials, equipment and some direct labor costs. A large part of the direct and most of the indirect labor costs in carrying out R&D projects is provided by the performing organizations. The prior year Japanese photovoltaic budget for the period of April 1981 through March 1982 was about $25 million.

Senator **Bumpers**. On that point, Mr. Chairman, you hit on the precise question I was getting ready to get into, and it is taken from an international comparison that is prepared by the Office of

Conservation. It is prepared for DOE, Office of Police Planning and Evaluation, Office of Conservation and Renewable Energy of the DOE, and it is prepared by a corporation called DHR.

Are you familiar with that report?

Mr. TRIBBLE. No, I don't believe so.

Senator BUMPERS. Well, if I could just follow up on what Senator Domenici has said here, I think it is really important, Mr. Secretary, and I hope that you will familiarize yourself with the report. I think it is a very well done report, but it says there is little evidence that other countries are planning to cut their conservation and solar programs. We have been by far and away the leader in money spent for research and development in conservation, and now, based on the budget that is being proposed to us, we are going to fall back almost to last of all the industrialized nations, and I don't see how you can do anything but put us at a further competitive disadvantage with countries like Japan and Germany.

There is a chart here on this, which indicates the total Federal Government R&D budget for energy conservation, and it compares the R&D budgets for a lot of countries from 1979 through 1981, but 1981 is not terribly instructive because there are too many statistics that aren't in from some countries for 1981. In 1980 we were spending $252 million per quad, and Japan was spending $32 million. France really was the only one that was even close to us at $92 million, and now at the rate the Reagan administration is proposing this budget here, we are going to go almost to the bottom of the heap between the United Kingdom, West Germany, Japan, Australia, Canada, Sweden, the Netherlands, France, and the United States. They said, in addition, on the subject of solar energy and conservation, further research is required to determine to what extent the U.S. private sector will pick up the slack created by the reduction in Federal R&D spending on conservation and solar energy.

I really think that the administration has taken a very tragic road here, and I would strongly urge you to become familiar with that.

If I might just go ahead for your own edification and for the record, the report further says,

> The Board concluded that R&D buildings and community systems need increased funding in view of the large amount of energy consumed in this sector and lack of private sector institutions able to undertake the building systems R&D.

Hospitals and schools, particularly schools, don't have the money to do the things that we would like for them to do.

Staff has asked me to clarify something. This is a report that the Energy Department paid for. They asked for it. It is from their own Advisory Board, the Energy Research Advisory Board, Research and Development Panel. That is what your own Advisory Board came up with.

Mr. TRIBBLE. ERAB [Energy Research Advisory Board]?

Senator BUMPERS. Yes. I was confused on where that language came from a moment ago.

Mr. TRIBBLE. In respect to that report, they have actually formed a second committee, one in renewables and one in conservation, and they did so at our request. We have asked them to come forward with specific recommendations.

You know, conservation and renewable energy is kind of like apple pie and motherhood.

Senator **Bumpers**. It's hard to be against it.

Mr. **Tribble**. But when you get down to the specific technologies—it is easy to recommend you spend more money on conservation and renewables, but then you get down to the specifics of where that should best be spent, sometimes this is the kind of thing we have asked them now to come back and tell us.

Senator **Bumpers**. I think that is a legitimate request on your part, and I admit these are generalizations, but they have made them in their summaries, and I think you are within your rights certainly to ask for them to be more definitive in what they would do, but photovoltaics, as Senator Domenici has pointed out, is one field I can tell you right now that I would be very definitely in.

One other thing, you know, the thing that worries me—I am not antifree enterprise. I am not antibusiness, but they make bottom line judgments on these things. You know the chairman and the president have to file an annual report with their stockholders, and the bottom line is everything. I know a lot of people who are presidents of these companies. Mr. Tribble, you know exactly what I am talking about, and if I had the kind of confidence that they are going to pick up some of these low-risk, short-term payoffs, I wouldn't be nearly as agitated about this, but I don't have any confidence that that is the case.

My most graphic experience with the private sector participation even in these where the Government was willing to put up the money is with the Clinch River breeder. We started off on a 50-50 cost-sharing thing with the private sector. Seven years later, what every, almost every consultant has said is that it is certainly a technological turkey, and we are going right ahead with it as though nobody had said anything, and it just has a life of its own. It's like Rasputin. You cannot kill the damn thing, and yet every scientist I have ever known says that when this is finished, it is going to be 15 to 20 years behind the French. Fred called it the CETA program for nuclear science.

Getting back to the point, we were going to go 50-50 on the Clinch River breeder with the private sector, the utilities, and we have now spent $1 billion on that. The first spade of dirt has not been turned, and the private sector contribution is all the way down to 10 percent. Out of $1 billion they put up about $100 million. We are proposing to spend another $3 billion, and I promise you they won't put up 3 percent of that, so you can understand why I am concerned about it.

Now to change gears—that's my sermon for the day, Mr. Tribble. You sat very patiently.

Senator **Ford**. I'm glad it was a sermonette.

Senator **Bumpers**. I'll give you the whole dose later, Ford.

Senator **Ford**. I don't have time.

Senator **Bumpers**. The other thing, Secretary Edwards was here, and I asked him—we are all fairly rhapsodic about the decline in the import of energy. I share the joy and the gratitude that we are all sort of feeling, self-satisfaction about it.

Senator DOMENICI. What was that word you used? Rhapsodic?

Senator BUMPERS. That's just an old Arkansas word we use.

Senator FORD. You have to be one to understand it.

Senator DOMENICI. I knew you wanted to ask.

Senator BUMPERS. Change it for all you non-Arkansans to euphoric, about oil imports which are 4.3 million barrels of oil end product for the past 4 weeks. That is indeed very gratifying to all of us, but there is a little kicker there.

No. 1, people aren't driving nearly as much and they aren't using as much because we have 10 million people out of work.

No. 2, the week before last plants in this country operated at 67 percent capacity as compared to 90, 95 percent when we have a good, stimulated economy.

I asked Secretary Edwards if he could break down how much of the conservation or what we feel is the reduced energy consumption, reduced imports, how much of that is due to economic conditions and how much of it is due to actual conservation. He said he couldn't answer that. I can understand why he couldn't. I guess that would be a very difficult thing.

Do you have any thoughts on that subject?

Mr. TRIBBLE. I do not know of any specific numbers. I think we would simply have to look at it in generalities. We know that we have made progress. We know that we have made progress per unit of production in industry. We know that we have made progress in miles per gallon of the fleet, and particularly with new automobiles in the transportation sector.

The airline industry has made substantial progress in this, cutting down on fuel per passenger mile, so that certainly some of it is due to conservation as you and I consider it to be, and that is improved efficiency of utilization.

On the other hand, there is no question that the economic conditions that we have today are responsible for a substantial decline in imported oil. I just simply do not have any numbers that sort it out so that we could allocate a percentage to each one.

Senator BUMPERS. Mr. Chairman, I had another question. It has eluded me for the time being.

Senator DOMENICI. Senator Ford?

Senator FORD. I want to endorse what the chairman and Senator Bumpers have said as it relates to several areas, that I think we are just cutting off our nose to spite our face, and the Government is not giving any leadership.

Going back to the question I asked you if the Department had conducted any studies or analysis which justify your position that the private sector will conduct the research that you are cutting, you said no. I think it is evident in what Senator Domenici has said and Senator Bumpers has said that we need to know that, and the progress we are making ought not be stalled at this particular time, and what you are going to get, if I get the impression here from at least three of us, is additional funds to proceed in this area whether you like it or not. Then I get back the report how are you going to handle the funds that we might give you in 1983 compared to 1982, based on the reduction of personnel that you have proposed?

Now I don't want to get into the catch-22 position that we are in about funding and then not gearing up an authorization, continuing resolutions, and then rescissions, and then you do what you damn please. I don't want that. I think it is time that we began to look a little more realistic at that. We understand what is happening and we understand what you know is going to happen, but I ask you one question. I am going to ask about three quick questions, and the fourth one I will be through, Mr. Chairman.

Mr. Secretary, can you tell me what the authorized staffing level of your area is? I don't need the numbers. Just answer me yes or no. Can you tell me?

Mr. TRIBBLE. I have the numbers. I do not keep them in my head.

Senator FORD. You can't tell me?

Mr. TRIBBLE. Yes.

Senator FORD. You can tell me the actual number that is on staff?

Mr. TRIBBLE. Yes.

Senator FORD. Can you give me the funds available for obligation?

Mr. TRIBBLE. Yes.

Senator FORD. Can you give me the number of funds actually obligated?

Mr. TRIBBLE. Yes.

Senator FORD. Can you give them to me every 30 days?

Mr. TRIBBLE. Yes.

Senator FORD. Mr. Chairman, I ask then that the Secretary be requested to present to this committee every 30 days, first, authorized staffing level; second, actual staffing; third, funds available for obligation; and fourth, funds actually obligated.

Senator DOMENICI. Well, Senator, I don't think I have authority to do that.

Senator FORD. I said ask him.

Senator DOMENICI. I have no objection to it. I would think if it was going to be official from this committee, it would have to go beyond us, but I will join in an informal way as the subcommittee in asking for it, and I would assume that if he has any concerns, he will tell us and we would ask the full committee to make it ratified.

Senator FORD. I would hope you would give me that by programs also.

Mr. TRIBBLE. I am not sure we have it broken out by programs.

Senator FORD. I see a nodding head here.

Mr. TRIBBLE. All right; good enough.

Senator FORD. That is yes also. I was not going to get into the posture, Mr. Chairman, of having to put a little hooker on a bill going through that would have that requirement in it. I think we ought to have the cooperation, and I think we can, and I believe you will do it, and I would hope we can get it on that basis.

Mr. TRIBBLE. I will be pleased to.

[The information follows:]

The following data will be provided at the end of each month for the remainder of fiscal year 1982:

Authorized Staffing Levels.—Authorized staffing ceilings are provided on an annual basis, expressed in full-time equivalents (FTE) at the organizational level of Conservation and Renewable Energy.

Actual Staffing.—Actual staffing will be provided at the office level, i.e., Office of Vehicle and Engine R&D, Office of Solar Heat Technology, etc.

Funds Available for Obligation.—Available funding will be provided by appropriation and program.

Actual Obligations.—Actual obligations will be provided as of the end of each month with submissions reflecting the latest data available at the time of each report period.

Senator FORD. Thank you very much, Mr. Chairman.

Senator DOMENICI. Mr. Secretary, we have a number of questions we will submit to you in writing. I would just like to ask you about two things.

Just two questions about alcohol fuels. What is the status of the negotiations with regard to the 10 companies for loan guarantees?

Mr. Secretary, do you have an answer to that question?

Mr. TRIBBLE. The answer is that all 10 are continuing in negotiation. There were 11. One dropped away, but the other 10 are continuing to be negotiated.

Senator DOMENICI. Well, why does it take so long?

Mr. TRIBBLE. I am not familiar with the details of that. We will be pleased to give you this for the record.

Senator DOMENICI. Would you do that, please?

Mr. TRIBBLE. Yes. I will be glad to.

[The information follows:]

Negotiations with the 10 companies that currently have conditional loan guarantee commitments are continuing. The number of participants in such negotiations are numerous and include the government, the loan applicant, commercial bankers, investment bankers, construction, and architectural engineering firms. This increases the complexity of negotiations which adds to the time required to develop a loan guarantee agreement that is acceptable to all parties and is in the best interests of the government.

In addition, the present economic climate has not been conducive for raising the equity required for the projects. As the predicted upswing in the economy occurs, the investment and banking community will look more favorably on construction projects of this type.

Senator DOMENICI. I think we really would like to know because it does seem like an inordinately long period of time, and if as a matter of fact there is some reason that the administration feels that these really can't reach fruition, we would like to know that also.

It is my understanding in that same regard that there are far more alcohol fuel facilities that are proceeding on their own, and that most of them are relying upon the exemption from the Federal gas tax which I assume is part of the so-called tax subsidy that is recommended by the administration for the Nation as a no longer needed tax expenditure.

Would you be able to check that out for us, see if many of those that are proceeding would conclude that there would not be market feasibility if the exemption were repealed?

Mr. TRIBBLE. Are you speaking of the 4 cents a gallon tax?

Senator DOMENICI. Yes, sir.

Mr. TRIBBLE. All right.

[The information follows:]

There presently are many alcohol facilities that are being planned and constructed without government loan guarantees. In any economic enterprise, potential producers examine all the private benefits and costs associated with a project before scarce resources are committed. As such, the 4 cent Federal excise tax exemption for fuels that contain at least 10 percent alcohol would be considered, with other tax benefits such as the new accelerated depreciation allowances, before resources are committed to these projects.

It is extremely difficult to determine whether private investors would consider the repeal of the Federal excise tax exemption as causing them to terminate their plans to construct fuel alcohol production facilities since most firms consider that information to be proprietary. We expect that the elimination of the exemption will further increase reliance on free market forces that permit the rational development of all energy resources.

Senator DOMENICI. I understand that many of them couldn't make it without it, and I think we ought to know that so we can communicate to our tax writing committees. It would seem to me there is a general desire that they proceed to build some in the country. It is not filled with as much, what was the word, "rhapsodicness" as it was a few years ago because we have become more realistic, but I think it is still there, and we would like to know if they need it so we don't wipe it out while they are in the middle.

Senator FORD. Mr. Chairman, that is phonics for rhapsody.

Senator DOMENICI. I see.

Mr. TRIBBLE. I'm sure you will find that they could use it. However, I must say that in the time that we have been negotiating, none has backed away in view of the prospect that this would be, this tax would no longer, this benefit would no longer be available, and further, I think there is a grandfathering provision in this that may not have been clearly defined at this time.

Senator DOMENICI. Will you tell us that in your response?

Senator FORD. Just the threat, Mr. Chairman, of the loss of this tax credit, is really creating havoc among those who are involved in large expenditures of money, and I would be very hopeful if we could eliminate the fear. Just like every morning you turn on the TV and you talk about social security. The old folks can't eat their breakfast.

There are several States that are involved surrounding Kentucky, Ohio, for instance, in Kentucky and other States where they are trying alcohol fuels and working very hard and converting distilleries and that sort of thing, and the very fact that you are going to, or the threat of inclusion of the 4 cents is causing them to take another look.

Senator DOMENICI. My last question has to do with some of the international commitments that we seem to have made. I met with the Chairman of the International Energy Agency a short time ago, and he expressed a concern that the United States be prepared to continue to support a number of research and development activities.

For instance, in the solar area, that is just one, but throughout the budget, the Department it appears to me at least has made no effort to maintain these international commitments. For instance, Solarex, solar desalinization work in that program, and another one was to be funded jointly by Germany and Japan in the geothermal area, hot dry rock. It was my understanding that an agreement was reached between the three nations not only for demonstration on that one, but continued operation to demonstrate the longevity of that source.

From what I can tell now, Mr. Secretary, the request in the budget would phase all of these out in 1983. Is that contrary to our IEA agreements or not?

Mr. TRIBBLE. I don't believe any of these agreements are with IEA. Actually they are agreements, the one on the hot dry rock is between Japan, Germany, and the United States, and in 1983, well, the holes have been drilled now for the hot dry rock experiment, and we now need to fracture, hydraulically fracture the rock between the two holes, and then circulate some water. We think that we will through 1983 gather enough information to be able to predict the viability of that process or that experiment.

If my memory serves me correctly, we have come in for 2½ million for 1983 for that activity, which would then be met or matched by a 1¼ million by both Japan and Germany, and we feel at this time that this will give us adequate information from there.

Now in the Solares program, as you know, this was a $100 million program entered into between Saudi Arabia and the United States, and it is going forward. We are asking for I believe $9,500,000 in 1983 which will be the final installment in that joint effort, and those programs that have been initiated in the Solarex program are going forward, but we did at one time think that we may be able to put in a desalinization plant both here and one in Saudi Arabia. It appears now that we may not be able to do both.

Senator DOMENICI. But at the minimum we are trying to do one?

Mr. TRIBBLE. Yes.

Senator DOMENICI. We have a number of additional questions, but I think in the interest of time we will submit them along with the other requests that we have made. We would appreciate your responses as soon as possible.

Thank you and Dr. Savitz both for being here and for your patience in waiting for us since we were late.

We stand adjourned.

[Whereupon, at 3:40 p.m., the hearing was adjourned, subject to the call of the Chair.]

[The information submitted for the record follows:]

APPENDIX I

ANSWERS TO ADDITIONAL QUESTIONS SUBMITTED FOR THE RECORD FROM JOSEPH J. TRIBBLE

Department of Energy
Washington, D.C. 20585

April 23, 1982

Honorable Pete V. Domenici
Chairman, Subcommittee on
Energy Research and Development
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed are the answers to questions submitted following the March 15, 1982, hearing before the Senate Energy and Natural Resources Subcommittee concerning the authorization for fossil energy, conservation and renewables.

Copies of the enclosed answers have been sent to the Subcommittee for the official record.

If you have any questions, please call Ingrid Nelson or Tom Pretorius of my staff on 252-4277. They will be happy to assist you.

Sincerely,
Thomas H. Pretorius
for
Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosures

cc: Mr. Paul Gilman
Staff Director
Senate Energy R&D Committee

Follow-up Q's and A's to Tribble March 15, 1982 Senate Energy & Natural Resources Hearing on Renewable Energy - Due 4/16/82

ACTIVE SOLAR HEATING AND COOLING

1. Q. Could you provide the Subcommittee with a list of the accomplishments during FY 1982 regarding the solar cooling program?

   A. The following list of accomplishments fall into four broad categories: absorbtion, Rankine, dessicant and heat pump cooling systems.

   In absorbtion cooling systems we have completed development and initial tests of the first breadboard model of 3-ton hybrid gas-solar double effect/single effect absoprtion chiller; completed fabrication and initial tests of the first 3-ton air cooled absorption chiller designed specifically for solar heated residential building(s); fabricated and completed tests of several high capacity water-cooled, solar powered absorption chillers with capacities ranging from 10 to 120 tons; designed, fabricated and conducted initial tests of 2nd generation, high-performance, air-cooled absorption chillers developed specifically for use with high performance evacuated tube solar collectors; and completed a system test, instrumentation, and test facility modification plan for an integrated system test of two prototype 3-ton air cooled absorption units powered by the low cost thin film solar collectors and evacuated tube collectors, respectively.

In our Rankine cooling systems effort we have completed design and partial fabrication of improved 18-ton Rankine air-cooled chiller for the Joint Saudi - American Solar Project and designed and partially fabricated a hybrid solar-fossil fuel boosted 20-ton Rankine chiller that offers a potential system efficiency higher than any existing air-cooled Rankine-solar chiller in the 15-25 ton size range.

In the dessicant cooling systems area we have conducted initial sub-system tests of the rotary spiral wound solid dessicant cooling unit. This unit is, according to both sub-system tests and computer model predictions, potentially the most efficient of any solar-cooling system. We have also conducted preliminary regional sub-system tests of four liquid dessicant cooling systems; initial results show that these systems are capable of both low cost and high performance. In addition, we have conducted a limited evaluation of the first chemical heat pump system; this innovative concept couples the liquid dessicant concept with the absorption heat pump for both space heating and cooling analysis and evaluation of the three solid dessicant cooling systems under development since 1977 have been completed.

Finally, in our heat pump program, we have conducted an initial evaluation of several conceptual systems of solar heat pump and thermal storage configurations. This analysis is to be completed this year and should provide both cost/performance goals and guidance for selection and sizing of heat pump system configurations. As a result of earlier research, we have designed, fabricated and tested a thin film, low cost collector prototype. A 500 ft^2 array is now being fabricated and will be tested in combination with an absorption chiller at Colorado State University's residential solar test facility. Installed costs for these collectors, when in production are estimated to be less than 1/3 the cost of the equivalent flat plate collector.

PASSIVE AND HYBRID SOLAR ENERGY SYSTEMS

2. Q. Could you provide the Subcommittee with a list of the accomplishments of the passive cooling programs?

A. Radiative Cooling

- Completed experimental program examining the characteristics of the sky as a radiative heat sink. The results are being summarized in algorithms which describe the dependence of the apparent sky temperature on local climate variables.
- Completed initial experiments examining the relative effectiveness of conventional and spectrally selective materials for use as radiators.
- Initiated research directed at producing samples of advanced materials that will enhance radiative cooling system performance.
- Initiated radiative cooling system preliminary design and analysis. Proof of concept experiments for one system have been completed and are under way for a second system.

2 (cont.) PASSIVE AND HYBRID SOLAR ENERGY SYSTEMS

Ventilation Cooling

- Completed initial full-scale experiments testing the validity of the natural ventilation research conducted at small-scale in wind tunnels.
- Identified and initiated testing of advanced natural ventilation systems for residential scale buildings which obviate concerns regarding security of buildings utilizing standard natural ventilation systems through ground floor opening.
- Initiated research to provide systems analysis capabilities for ventilated buildings. These capabilities are being developed in order to permit improved quantification of the heat transfer characteristics of ventilation systems.

Earth Contact Cooling

- Completed heat transfer research producing advanced algorithms describing the thermal interaction of dry soils in contact with buildings.
- Initiated experimental testing of earth contact buildings of residential scale in order to quantify their performance in comparison to the predictive algorithms referred to above.

2 (cont.) PASSIVE AND HYBRID SOLAR ENERGY SYSTEMS

- Initiated research on the apparent thermal response of soils with combined heat transfer and moisture transport.

Cooling Load Control

- Completed preliminary systems analyses examining the impact of solar gains on the consumption of conventional fuels for cooling of residential and commercial buildings. The results are being interpreted in terms of (1) needs for advanced aperture materials, and (2) guidelines relating to use of conventional techniques for controlling solar gains during periods when they are undesirable.
- Completed fabrication of test facilities for measuring (1) the natural illumination environmental resource and (2) illumination levels obtainable in scale models of advanced natural lighting designs.
- Initiated systems analyses directed at optimization of natural lighting systems, including their impact on heating and cooling energy consumption in commercial buildings.

3. Q. What initiatives has the Department undertaken to assure that existing information and data are made available to the appropriate end use sectors for these programs?

A. A major initiative to document the advances in solar thermal energy conversion for buildings, has been undertaken by the Office of Solar Heat Technologies. The work will cover the research, technology development and utilization of solar energy resulting from 10 years of government programs including the Passive and Hybrid Solar Energy Program. The government supported efforts will be critically reviewed and the morse important technological advances and their impacts on the state of solar energy research, the solar industry and the use of solar energy in the Nation will be reported in detail. The target audience for this series of publications includes researchers, manufacturers, and decision makers.

The Passive and Hybrid Solar Energy Systems Program is also undertaking or participating in several activities designed to assure that research outputs become available to end use sectors, i.e., the various specialities making up the building industry. Information is provided for articles in the popular trade and technical press. Technical information and handbooks are being developed by the Program. A library of all publications resulting from passive solar research activities has been initiated in cooperation with the Passive Solar Industrial Council, a consortium of building industry trade and professional service organizations.

3 (cont.)

Further, four libraries are being preserved from the four Regional Solar Energy Centers which are currently in the process of termination. The libraries will be turned over to public institutions under arrangements requiring that they be made available throughout their respective regions.

Inquiries from the public on the full spectrum of renewable energy technologies and energy conservation are answered by the Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS). In addition, teh Technical Information program at the Solar Energy Research Institute (SERI) transfers important research-oriented solar information to the technical audiences that can apply it, in formats suitable for their use. The CAREIRS and SERI information programs will continue through the end of Fiscal Year 1982. The Department proposes to phase them out in FY 1983. However, the contractor who is operating the CAREIRS program is currently seeking private funding sources to allow this service to continue.

Given the growing availability of solar information in the private sector, no further Federal effort is warranted. The Department will continue to disseminate the results of R&D programs through the National Technical Information Service and through the National laboratories within the provisions of the Stevenson-Wydler Technology Innovation Act of 1980.

4. Q. In closing out the active and passive solar programs, has the Department given any consideration to the marriage of the different technologies? For example, has there been any effort to provide simplified models to home builders for predirting the optimum mix of passive solar heating, cooling, daylighting, and conservation?

A. A primary thrust of the Passive and Hybrid Solar Energy Systems R&D Program has been to develop simplified predictive models and associated design tools which can ultimately be used to optimize the mix of passive/conservation technologies. As a result of this program, there are now available several design manuals and computer programs which can provide valuable assistance to home builders.

5. Q. There has been an expression of concern on the part of home builders and associated industries that information already gathered in the conservation programs and in the passive solar program, for instance, is not flowing to the industry. They have a further concern that without DOE research there will be very little further work done in the areas directly related to residences. They argue that the home building industry is so diverse and made up of so many small businesses that no overall effort could be put together to perform research in a way that say the Electric Power Research Institute does for utilities. Would you please provide the Subcommittee with the Department's position on this?

A. We believe that the various industry and technical trade associations realize the expanded role they need to play in the future and will be able to perform the various functions associated with information and technology transfer. DOE will continue to disseminate the results of R&D programs through the National Technical Information Service and the Technical Information Center as in the past. Given the availability of energy conservation and solar information in the private sector generally, general information requests should be channeled to industry and consumer sources already widely distributing such information. The only part of these activities being transferred to the private sector is the packaging of the information reported by the Department in forms desired by ultimate users. We believe the likelihood of this packaging being adequate will be greater when the users have a choice among competing services.

DOE will continue to perform high-risk, high payoff R&D. The building industry, although highly diversified, has independent research activities underway. DOE anticipates that as the Federal R&D activities are reduced, these associations will expand their research activities. These associations represent the collective interests of builders, architects, engineers, energy suppliers, and manufactuers. Many of these associations already have independent research activities, for example the National Association of Home Builders Research Foundation, the American Institute of Architects Research Corporation, the American Society of Heating, Refrigerating and Air Conditioning Engineers, the Gas Research Institute, and the Electric Power Reserach Institute. In addition, private companies, such as General Electric, Honeywell, and Whirlpool, are expected to expand their R&D activities as higher energy prices stimulate the market for more energy efficient products. DOE has discussed its plans for reduced R&D with architects, engineers, and product developers in a general way. In informal discussions with private sector building association members and other information received by DOE, there appears to be a trend of growth in the various building sectors;

i.e., solar heating and cooling, passive solar installations, new passive products, building energy control systems, insulation products, etc. Along with this growth, there are indications that additional research and development will be stimulated in these and other building sector areas.

PHOTOVOLTAICS

6. Q. In reviewing the Department's FY 1983 Budget Request, the General Accounting Office said, "One technology that will probably develop more slowly with reduced Federal support is solar photovoltaics. Recent GAO work indicates that the industry is reluctant to make additional investments due to the high uncertainties and risks associated with making this technology economical. Consequently, the widespread use of photovoltiac energy systems will likely be delayed." What are the recent trends in industry investment as seen by the Department? Your testimony indicates that the industry invested approximately $100 million for research and development, production facilities, and marketing in 1981. Last year during oversight hearings on the FY 82 budget, the Department provided information that the industry had invested nearly $300 million in R&D. Could you explain the difference in these two estimates?

A. The estimate of $100 million for industrial investment is for the calendar year 1981 whereas the $300 million estimate is for a five-year period from 1977 through 1981. Private conversations with industry executives suggest a continuing high level of private investment. Exact numbers are proprietary therefore unknown however, we do not expect a downturn in 1982.

7. Q. Could you provide the Subcommittee with the relative world market share attributed to U.S. photovoltaic manufacturers over the past five years?

A. We estimate the world market share of U.S. photovoltaic manufacturers to be greater than 80 percent over the past five years.

8. Q. What is the likely trend in the future?

A. Statements by staff of the European Community indicate a rapid increase in the number of European cell and module producers, from about 5 companies in 1980 to several times that number in 1983. Similarly, around the world, new manufacturing facilities have been announced recently in a number of other countries including Japan, India, Australia, Brazil, Spain and Canada. Thus, the number of photovoltaic manufacturing companies around the world could increase from 15 (about 10 in the U.S.) in 1980 to as many as 50 (about 20 in the U.S.) by the end of 1983.

U.S. companies will need to continue competing vigorously overseas in both product quality and price to maintain a substantial future overseas market share and a dominate position in the U.S. market.

9. Q. What is the structure of the government research and development programs for photovoltaics in foreign countries? Are the efforts being undertaken by Japan and in Europe placing the greater emphasis on marketing and systems development? What are the funding levels being provided by major foreign producers of photovoltaics for their research and development programs?

A. The structure of the government research and development programs for photovoltaics in foreign countries consist (for each country) of program elements in advanced research, technology development, systems development and test and applications. Their objectives emphasize cost reduction. In addition, Europe and Japan are now building numerous experimental projects. Most projects are grid-connected and include roof mounted residential systems, intermediate systems up to 300 kWp and several megawatt size central utility project.

There is no evidence to suggest that Japan and Europe is placing greater emphasis on marketing and systems development. It is believed they are pursuing balanced programs which include appropriate emphasis on research.

A number of foreign countries are rapidly increasing their photovoltaic budgets in 1981 and 1982. The Japanese government budget has increased from about $12 million in 1980 to about $29 million in 1982. The spending by European countries on photovoltaic technology development is not well documented and is spread among individual countries and the European Community, which have an extensive R&D and test and applications effort. A general estimate of the aggregated budgets is about $50 million.

Department of Commerce Trade Development

10.Q. Although we have phased out market development activities in the Department of Energy, there has been a long-established program within the Department of Commerce to help promote the sale of U.S. technologies overseas. The Department of Energy's program in the solar area during FY81 resulted in the sales of $3 million "off the floor" at various trade shows, and the GAO has projected that the 12-month future sales resulting from those shows would be about $60 million. Are you presently assisting the Department of Commerce in their efforts to continue such trade development programs in solar and conservation technologies?

A. The DOE is familiar with the historical trade development programs operated by the Department of Commerce (DOC). In past years, the DOE has provided substantial technical assistance and seed money to DOC to better enable them to introduce the emerging renewable energy technologies into the mainstream of their trade development program. As reported in the referenced GAO report, the DOC has begun an exploratory follow-on program to determine the return on DOC investment associated with a permanent full scale trade development program for commercially available renewable energy technologies.

The DOE believes that the Department of Commerce is the appropriate federal organization to conduct such programs, and concurs in the approach taken to date. This Department stands ready to provide technical advice and assistance to DOC, particularly with regard to the research programs supported by DOE. We envision no need for DOE funding requirements in this area most competently administered by the Department of Commerce.

Biomass

11. Q. In the past the Gas Research Institute has jointly funded work in the biomass area. Will the Gas Research Institute continue this joint research in FY83? If not, why not?

A. The Department of Energy (DOE) and the Gas Research Institute (GRI) have jointly funded an ocean farm project which tested the feasibility of offshore growth and reproduction of kelp for renewable energy supplies. This project also evaluated the capability of the anaerobic digestion process for the high rate conversion of kelp to methane. The results of these studies indicated that kelp digestion compared favorably with other types of biomass with regard to methane yields. GRI has assumed responsibility for the ocean kelp project. DOE and GRI are presently funding a project which provides for the use of water hyacinths for the treatment of sewage and the subsequent conversion of these plants to methane. This project will be completed in FY 1982. GRI will continue to support research on biomass production and conversion technologies. DOE Biomass program staff exchange technical information with GRI researchers regularly and they will continue to coordinate the production and conversion activities of the federal research effort with the GRI biomass program.

WIND ENERGY TECHNOLOGY

12. Q. The press has reported a number of initiatives on the part of private companies to provide wind generated power to utilities. How far have these proposals advanced? How important are the existing wind energy tax credits to these proposals? How important are the provisions of the Public Utility Regulatory Policies Act of 1978 (with regard to the requirement that utilities buy power at "just and reasonable rates" from small power producers)?

A. A number of electric utilities and private groups are actively considering wind generated power projects. Several small wind farms are now in operation in California and New Hampshire, and the Southern California Edison Company, Pacific Gas and Electric Company and the Hawaiian Electric Company are actively considering obtaining additional power from private entrepreneurs.

The business tax credits for solar and conservation provide an added incentive for private sector investment and improve the market potential for such technologies as wind. However, without the tax credits, wind farms to produce electricity for sale to utilities can still be economically feasible and the private sector would be expected to continue such efforts.

The small power producers provisions of the Public Utility Regulato Policies Act are generally considered to increase the prospects for use of all types of renewable energy systems for power generation, including wind energy. The impetus for wind farm development in several states (California, Hawaii and New Hampshire) can be partially attributed to PURPA.

OCEAN ENERGY SYSTEMS

13. Q. In November of 1981 the Department notified this Committee that it did not have the statutory authority to transfer title of OTEC-1 to the State of Hawaii. Has the Department developed statutory language which would authorize this transfer?

A. On February 10, 1982 S.2096 was introduced in the Senate and H.R. 5524 in the House to authorize the Secretary of Transportation to transfer to the State of Hawaii the United States Ship (USNS) Chepachet (OTEC-1). S.2096 was referred to the Committee on Commerce, Science and Transportation. H.R. 5524 was referred to the Committee on Merchant Marine and Fisheries.

14. Q. What is the status of efforts by the private sector to develop commercial ocean thermal energy conversion units?

A. On February 18, 1982 the Department of Energy selected two contractors to perform a conceptual design for a closed-cycle Ocean Thermal Energy Conversion Pilot Plant. The two contractors who were selected are, the Ocean Thermal Corporation, consisting of TRW, Inc. as the systems integrator with TRW, Hawaiian Dredging, Burns & Roe, R. J. Brown Associates and Science Applications, Inc. as the subcontractors and General Electric, consisting of General Electric as the systems integrator with Brown and Root, Hawaiian Dredging and Gibbs and Hill as subcontractors. It is anticipated that contracts will be awarded to these two consortia under a cost sharing arrangement during the third quarter of FY 1982. Each of the companies is expected to participate in this cost share in some form. Independent of this activity, World Wide Protein has announced plans to build a combined OTEC-Desalination-Mariculture plant off the coast of St. Croix, Virgin Islands.

15. Q. What is the status of the OTEC licensing regulations?

A. Under P. L. 96-320, Ocean Thermal Energy Conversion (OTEC) licensing regulations are prepared and administered by the Administrator of the National Oceanic and Atmospheric Administration (NOAA). Regulations for the licensing of OTEC facilities and plantships were issued in 4GFR147, pp. 39388 et. seq. on July 31, 1981.

Alcohol Fuels

16. Q. What is the status of the negotiations with the ten companies for loan guarantees? What would be the effect of repealing the exemption from the Federal gasoline tax on these projects?

A. Negotiations with the ten companies that currently have conditional loan guarantee commitments are continuing. The number of participants in such negotiations are numerous and include the government, the loan applicant, commercial bankers, investment bankers, construction, and architectural engineering firms. This increases the complexity of negotiations which adds to the time required to develop a loan guarantee agreement that is acceptable to all parties and is in the best interests of the government. These negotiations should be completed by the fall of this year.

It is extremely difficult to determine the effect that the repeal of the Federal excise tax exemption would have on the ten alcohol fuel projects. Before investing in a project, private investors estimate its future profitability. These estimates are based in part on signals received from the marketplace. While the repeal of the 4 cent per gallon Federal excise tax on fuels containg at least 10 percent alcohol may discourage investment in alcohol fuels, the liberalized depreciation allowances in the Economic Recovery Act would tend to encourage investment in projects of all types. However, the elimination of the exemption will further increase reliance on free market forces and will permit the rational development of all energy resources.

Geothermal

18. Q. Would you summarize for the Committee the major findings of the research involving geopressured resources?

A. Known geopressured resources under study are the hot water aquifers, containing dissolved methane trapped under high pressure in deep sedimentary formations, located along the Gulf Coast. The initial results from well testing have shown that the geopressure acquifers are more saline than anticipated, but that they are fully saturated in methane. It has also become evident that the actual reservoirs are larger than previously thought.

Geothermal

19. Q. The Department of Energy is carrying out its Hot Dry geothermal technology program in cooperation with the Federal Republic of Germany and Japan. The draft implementing agreement has been drawn between the participating parties and in the annex to that agreement a number of goals and milestones are proposed. Among those goals: (1) a 6-8 month operation of the phase 2 loop at the Fenton Hill Project to define minimum life for the reservoir, (2) testing of the phase 2 reservoir for 2 1/2 years beyond this point, (3) carrying out various supporting activities such as data processing, laboratory studies, instrumentation development, and environmental surveillance through fiscal year 1987. The Administration has proposed to terminate the Hot Dry Rock technology program in fiscal year 1983. Has the Department conferred with participants in this program regarding this proposal? What has been the response to this proposal on the part of those participants? Would you provide the Committee with any pertinent correspondence between the participants on this matter?

A. Representatives of both the Federal Republic of Germany (FRG) and Japan have been briefed on the proposed FY 1983 budget and the implications of that budget. Neither country has as yet responded officially. The FRG has requested more information about the proposed budget (see Attachment). That information will be provided and discussed at the next Steering Committee meeting.

Geothermal

17. Q. The administration request for FY 83 does not include funds for the Heber geothermal demonstration project. Does the Department plan to use funds made available by the cancellation of the BACA geothermal demonstration project for Heber? What is the nature of private sector involvement in the Heber project? Does the Department propose to change the financial arrangements with the private sector if this project continues?

A. Yes, DOE would like to use some of the remaining funds from the BACA project for Heber. Reprogramming requests are being proposed. DOE has an industrial partner, San Diego Gas and Electric Company. Other participants in the project are the Electric Power Research Institute, Imperial Irrigation District, California Department of Water Resources, Southern California Edison, Nevada Power Company State of California, Chevron Resources, Union Oil Company, and New Albion Resources Company. Costs are shared 50% by DOE and 50% by the industrial partners. DOE is proposing to the industrial partners that the Federal funding for the project be completed in FY 82 and the cooperative agreement be renegotiated to reflect reduced government involvement in the project.

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US DEPARTMENT OF ENERGY, WASHINGTON DC
MR. ALLAN JELACIC [illegible]
ADVANCED ENERGY SYSTEM BRANCH
MR. JAN W. MARES (FOR INFORMATION)
ASSISTANT SECRETARY FOR FOSSIL ENERGY

DEAR MR. JELACIC,

WITH REFERENCE TO YOUR LETTERS DATED JAN. 6, 1982 AND FEB. 23, 1982 WE HAVE NOT RECEIVED ANY SUPPORTING MATERIAL WHICH IS NECESSARY FOR US TO PREPARE FOR THE STEERING COMMITTEE MEETING.

KFA AS A CONTRACTING PARTY TO DOE SHOULD BE COMPLETELY INFORMED ON PROPOSED CHANGES TO OUR JOINT PROJECT ON HDR-TECHNOLOGY. THEREFORE, WE WOULD APPRECIATE TO RECEIVE THE ANNOUNCED SUPPORTING MATERIAL BEFORE APRIL 12, 1982 BECAUSE DR. STOECKER WILL LEAVE GERMANY TO TRAVEL FROM CANADA TO WASHINGTON.

TO PARTICIPATE AT THE MEETING AT LEAST THE FOLLOWING INFORMATIONS ARE REQUIRED:

- WORKING PROGRAM AND FINANCIAL DATA (COST AND MANPOWER) FOR US FY 82 ESPECIALLY FOR THE ''57-DAY-PROGRAM''
- WORKING PROGRAM AND FINANCIAL DATA (COST AND MANPOWER) FOR US FY 83 AND US FY 84

- WITH REFERENCE TO ARTICLE 10 OF THE IMPLEMENTING AGREEMENT WE WOULD LIKE TO RECEIVE DETAILED INFORMATIONS ABOUT CUT-BACKS OF DOE'S SHARE TO THE PROJECT.

WITH RESPECT TO THE ORGANISATION OF THE STEERING COMMITTEE MEETING ON APRIL 22, 1982 WE WOULD LIKE TO INFORM YOU THAT THE KFA REPRESENTATIVES WILL BE DR. STOECKER, MR. BIERAAD, DR. SCHLOEMER ACCOMPANIED BY MR. KEPPLER FROM LAS ALAMOS. DUE TO THE NESSARY INTERNAL DISCUSSIONS WE WOULD LIKE THE MEETING NOT TO START BEFORE 11 A.M.

BEST REGARDS

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REPLY VIA WUI-DIAL 710-990-3535

Geothermal

20. Q. Has the Department initiated any discussions with utilities regarding the possibility of constructing a small electrical demonstration plant? What is the likelihood of utility participation in the event that the supporting technology program is terminated in fiscal year 1983? Has this question been put to any utility?

A. In April 1980, the Plains Electric Generation and Transmission Cooperative (Plains) was awarded a DOE grant for a study entitled, "A Hot Dry Rock Geothermal Electricity Generation Demonstration Project at Fenton Hill, New Mexico." The study examined institutional, legislative, and regulatory requirements affecting the completion of a demonstration project at Fenton Hill. Mr. Stanley K. Bazant, Executive Vice President of Plains, has stated that the utility has a continued interest in completing such a project at its own expense. However, to change that interest to a commitment Plains would require long term demonstration of hot dry rock production capability as well as technical assistance during the transition to industrial development.

21. Q. In the documents supporting the Administration's Budget Request for FY 83 it is stated that the superconducting generator presently under construction at MIT will be completed in FY 82. It is our understanding that component fabrication will be completed at that time, but that assembly will not have begun. Will the the Department require funding to complete assembly and testing in FY83? If not, why not?

A. We are not asking for further funds to complete this work. While it is true that only module assembly will be completed, we feel that the private sector or the Electric Power Research Institute will want to complete the fabrication and initiate the testing.

22. Q. In the conservation area there are a number of programs which have been maintained at a low level for a number of years which never really have caught the public eye, an example is the electrical energy systems program and the storage program. The Department is proposing to phase those out, and your statement says the justification for that is the private sector will pick up that research. The private sector in this case is principally the regulated utilities. Furthermore, a number of activities under these programs would seem to directly affect national security issues and health and safety issues. For example, this budget request would terminate the research into the biological effects of high voltage transmission lines, and it would phase out research on the effects of electromagnetic pulses resulting from nuclear attacks. How does the Department envision that utilities and associated industries will do such research?

A. The research on the biological effects of high voltage on living organisms is an extensive program investigating the effects of 60 Hz alternating current and direct current electric fields from high voltage power transmission lines on plants and animals, and to assess whether the expected operation of present and future high voltage lines pose any significant risk to humans. Effects have been replicated in various small animals. Remaining research will be devoted to determining whether these effects pose any hazards to living organisms. This work is closely coordinated with EPRI large animal (swine) research where more dramatic effects have been noted but not replicated. We are encouraging the private sector to increase their participation in this important activity and to incorporate an appropriate mechanism so that a perception of unbiased objectivity is achieved.

Regarding the electromagnetic pulse (EMP) research, the FY 1982 funds will complete an assessment of the national problem. We intend to then turn this over to the Department of Defense.

23. Q. The Automotive Propulsion Research and Development Act of 1978 authorizes research and development in advanced automobile propulsion systems. The Act specifically requires that activities conducted by the DOE supplement but not supplant or duplicate private sector efforts. No funds have been requested for vehicle propulsion technology development. Does this mean that the private sector has taken up these efforts?

A. The advanced automotive propulsion systems programs will accomplish major milestones during FY 1982, and industry will have available dynamometer test data on prototype advanced engines and components for their evaluation. In FY 1983 funds have been requested to continue research work on critical technology barriers associated with ceramics and advanced materials as part of the Energy Conversion and Utilization Technologies program. The private sector is expected to undertake the final development and commercialization of these technologies consistent with their market potential. The future participation by industry in such technology development without government support will, of course, be a direct function of economic health.

24. Q. Why has the Department proposed to terminate the Stirling engine program? Has the program failed to meet its technical goals? How does the introduction of this engine technology into the market provide greater challenges for the development of a maintenance infrastructure than does the wide-scale introduction of diesel engines?

A. With the Administration's actions to free the energy marketplace, Federal Government support of technology research and development aimed at accelerating the introduction of new transportation technologies into the marketplace is no longer necessary. The Stirling engine program is one such technology. The program itself has met its technical goals. However, concerns such as manufacturability and costs are still unanswered.

The wide-scale introduction of diesel engines in automotive fleets can take advantage of the experience and maintenance infrastructure developed over the years for the trucking industry which is heavily dieselized. The introduction of Stirling technology will have no such advantage.

25. Q. Will the major companies continue research in gas turbine engine technology in the absence of a DOE program? Has the Department communicated with the major auto companies in this regard? If so, could you provide those communications to the Subcommittee?

A. Industry's investment in near-term, market competitive activities in the present economic environment will tend to decrease their long-term high risk research and development budgets. Although both Ford and General Motors have applied considerable internal funding to gas turbine development in the past, present economic conditions have severely limited such support. It is expected that the continuation of research in gas turbine engine technology in the absence of a DOE program will be a function of the rate of economic recovery which will free private R&D funds for such project

DOE has not formally communicated with the major auto companies with regard to a commitment on their part in the absence of a DOE program. However, in informal discussions and presentations before Congressional Committees, representatives of these companies have indicated that it would be very difficult to continue automotive gas turbine technology development at the same level without government support in light of the present scarcity of internal R&D funds.

26. Q. What are the plans of the major auto manufactures as of this time with regard to the production of electric vehicles? Has the Department had any indication that the final rule including electric vehicles and the calculation of the corporate average fuel economy (CAFE) has had an effect on major automotive corporations" production planning for electric vehicles?

A. The Truck and Coach Division of General Motors is developing an electric van with production to begin in Model Year 1985. GM provided the electric vans for the cost-shared demonstration by AT&T in the DOE program. Cooperative efforts by GM and DOE in the development of nickel-iron battery technology for potential use in the van is currently underway. The market introduction of the electric passenger car has been deferred until the late 1980's by General Motors. The technology of their nickel-zinc oxide batteries requires more development to increase battery life and reduce costs. The Ford Motor Company has recently signed a cost shared contract with DOE to develop an advanced a.c. propulsion system for an electric passenger car for potential production in the late 1980's. Although Chrysler and American Motors continue to monitor electric and hybrid vehicle technology developments, these firms have no definitive production plans. The commitment of resources for the development of electric vehicles by any of the major automakers is very limited due to the financial position of the entire domestic auto industry. Thus, the actual commitment of resources to plant and equipment for production of electric vehicles has not been made by any of the major automakers.

The auto industry was very interested in the determination of the final rulemaking including electric vehicles in the calculation of CAFE. Since the product mix of models for this calculation is proprietary information for the late 1980's and beyond, the DOE cannot determine the effect of this rule on their planning for electric cars. The public statements of the automakers are that the consumer's demands for more fuel efficient cars will facilitate their meeting of the 27.5 mpg CAFE standard with conventional cars. The decision to produce electric cars will be based on their assessment of consumer demand.

27. Q. In regard to the priorities in the Department's plans to continue some research on battery storage, could you explain why such technologies as the aluminum air battery are being proposed for termination at the same time we are planning to continue lead acid battery research?

A. In FY 1983 the Department plans essentially to complete work on the on-going lead-acid battery-development efforts for passenger electric cars. R&D on lead-acid batteries has resulted in a 50% improvement in cycle life over conventional lead-acid batteries and 25% cost reductions for advanced batteries. It is believed that the $1.5 million in the FY 1983 budget will be the final or near-final increment for this lead-acid battery technology and allow consummation of prior results. Demonstration, market testing, and further product improvements will be left to private industry.

Aluminum-air batteries will continue to be explored in FY 1983 at a level of $200,000. This will allow a determination to be made as to the future viability of this advanced technology.

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

WEDNESDAY, MARCH 17, 1982

U.S. Senate,
Subcommittee on Energy Research and Development,
Committee on Energy and Natural Resources,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2 p.m., in room 3110, Dirksen Office Building, Hon. Pete V. Domenici, presiding.

Present: Senators Domenici, Nickles, Ford, and Melcher.

Also present: Paul Gilman and Elliot Chakoff, professional staff members; James T. Bruce, counsel for the minority; and Willis Smith, professional staff member for the minority.

Senator Ford [presiding]. Senator Domenici is on his way. He asked us to go ahead in the essence of time. Senator Melcher has a statement. We will allow him to present that, and probably Senator Domenici will be here by that time.

STATEMENT OF HON. JOHN MELCHER, A U.S. SENATOR FROM THE STATE OF MONTANA

Senator Melcher. Thank you very much. I appreciate the opportunity to make this statement on behalf of the magnetohydrodynamics program, the MHD program, which the administration has proposed to phase out in the 1983 budget.

I understand they have already stopped spending 1982 funds and will ask for a recission of funds, and then for a reprograming of $7.6 million to terminate the program and shut down the facilities in Montana and Tennessee, as well as whatever other program parts are being operated in Massachusetts, Illinois, Mississippi, California, and so on.

The significant statement about this program was spelled out in the sunset report mandated by Congress in title X of the Department of Energy Organization Act. The Department said, and I quote:

> MHD, if commercialized, would benefit the Nation's health, safety, and environment. The MHD/steam powerplants have the potential to more than meet all environmental standards; and, if they achieve the projected high operating efficiency, there would be a reduction in atmospheric emissions, coal mining, and water usage per unit of electricity produced.

With this promise for solving one of our chronic environmental problems and providing some basic technology for improving the efficiency of electric power generation, it is still a very high risk development. In the same sunset report the Department said of the program:

> Although the private sector has the capability of developing the MHD/steam powerplant technology and other advanced technologies on its own, it appears unlikely to do so because of the large development costs and the remaining technology risks.

Mr. Chairman, according to the Department's own criteria, the MHD program should be one of prime candidates for continued funding.

When the Secretary of Energy appeared before the Energy Committee last year and then again earlier this year, he stated the administration's policy is realining the fossil energy budget, quote:

> To concentrate on long-term, high-risk research and development, while relying on the private sector to demonstrate and commercialize promising individual technologies and processes.

The administration's logic escapes me when we repeatedly read of MHD being referred to as one of the four advanced fossil energy technologies that offer significant potential for reducing the cost of electricity and improving the the environmental performance of coal-fired powerplants.

The MHD program has had several significant accomplishments over the past year. Coal combustor development work has demonstrated design feasibility with good performance of critical combustor parameters such as plasma conductivity, slag rejection, heat loss, and high carbon conversion efficiencies.

The recently completed 1,000-hour test at the AVCO site which simulated coal-fired MHD channel operations by injecting fly-ash and sulfur into an oil burner was extrapolated to a channel life of more than 8,000 hours.

Efficient superconducting magnets for use in the MHD process have been successfully demonstrated with the performance of a 40-ton, 5-tesla superconducting magnet shipped from the United States to the U.S.S.R. as part of the cooperative program, and more recently by completion of initial checkout of a 200-ton, 6-tesla magnet built by the Argonne National Laboratory. Preliminary checkout of the 6-tesla magnet showed that it exceeded design specifications by producing a 6.2-tesla field.

This superconducting magnet is now setting idle with no funds to ship or install it. Instead of producing needed engineering data like other major test facilities in the program, a major component part lies idle.

Other facilities and test data include heat and seed recovery and environmental performance data from the coal-fired flow facility in Tullahoma, Tenn.; high energy extraction performance data from the high performance demonstration facility at the Arnold Engineering Development Center; and 50-megawatt MHD power train performance data from the component development and integration facility in Butte, Mont.

At the CDIF in Butte, recent tests in February of this year achieved power outputs of 1.5 megawatts. Tests scheduled for later this spring will include activation and testing of an EPRI supplied inverter which will allow the MHD produced power to be put onto the commercial grid.

Other major activities in the CDIF have been concentrating on activation of the coal system in preparation for coal-fired testing some time next fiscal year. It is clear that the technology is advancing on all fronts and is now producing the much needed engineering data.

The reason the first coal combustor to be tested at this power level has been delayed is because of the vastly short fiscal 1982 funding level.

There is a wealth of information of the advances in the MHD technology both in this country and overseas. Programs are moving forward in Japan, Russia, Poland, China, India, and the Netherlands. The most ambitious programs are in Japan and Russia. There is little need to reiterate this information here. There are many others who will speak to this program either here or before the Appropriation Committee and will bring out all of this information.

Mr. Chairman, over the next 30 to 40 years this country will become more and more dependent on coal as the means to generate our electric energy. There are many fossil technologies that should be developed that can lead us to energy independence. MHD is one of those that has major potential for producing electric power which is such an integral part of our everyday life.

Certainly conservation is important and should be pursued so long as it remains cost effective to do so.

We will need major new energy additions to our baseload generating capacities when conservation has been extracted and the economy gets back on the track.

This program should be continued at a level that will allow the work to move forward at a reasonable pace to bring it on line for commercial use in the late 1980's. There are now power companies that stand ready to use the technology if the R&D and the testing are completed. Where we, as a nation, continue to deal with national energy problems, we have a public responsibility to see that technology is at hand when it is commercially expedient to incorporate it into new or existing facilities.

With the pressure on public service commissions to keep utility rates as low as possible, it is unreasonable to expect the power companies to perform this high risk and potentially costly work. If there was a program that merited continuation, this is it. Thank you very much, Mr. Chairman.

Senator DOMENICI [presiding]. Thank you very much, Senator Melcher. I assume that we have the Assistant Secretary of Fossil Energy, Mr. Mares here. We will proceed with your testimony, and your group will move to the table.

I don't have any opening remarks. We look forward to your testimony and we will have some questions.

Senator Ford, do you have any opening remarks?

Senator FORD. No. Thank you.

Senator DOMENICI. You may proceed.

STATEMENT OF HON. JAN W. MARES, ASSISTANT SECRETARY, FOSSIL ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DONALD BAUER, ACTING DEPUTY; AND CARL GUIDICE, ACTING DIRECTOR OF MANAGEMENT AND PLANNING

Mr. MARES. Thank you, Mr. Chairman. As you have noted, we have submitted a detailed statement describing the individual components of our 1983 budget submission, which I would ask be included in the record.

Although the formal statement is admittedly lengthy, we recognize that the committee has many questions about our budget submission, and we have attempted to address these questions in as much detail as possible. We are also prepared to discuss the proposed changes in the 1982 budget which we believe are necessary to insure a smooth transition to 1983.

Rather than summarize each of the line items included in the formal statement, Mr. Chairman, I would propose spending a few minutes describing the policy considerations that form the backdrop for this budget. After that, I will be pleased to respond to any questions you or members of the committee may have. If I am not able to respond fully to your questions members of my staff are here who can provide additional details.

With me at the table are Mr. Donald Bauer, my Deputy, and Mr. Carl Guidice, the Acting Director of Management and Planning. Behind me are each of the Fossil Energy office directors who are probably familiar faces to many members of this committee.

In formulating this budget, there has been no fundamental departure from the view this committee and others have expressed on numerous occasions, namely that fossil fuels will continue to be the dominant suppliers of energy in the United States for decades to come.

I've included a graph in the opening section of my statement which shows the midrange projections of the Department's National Energy Policy Plan. It illustrates graphically this point.

The key distinction between this budget and previous ones is that it recognizes there are better mechanisms than direct Federal funding to move fossil energy technologies into commercial use. We've devoted a portion of the opening section of our statement to describing such mechanisms; the decontrol of energy prices; leasing and regulatory reform; tax incentives, and the role of the Synthetic Fuels Corporation. Many of these have been made possible by the support of this committee, and each will play a major role in assuring that fossil fuels are able to compete and thrive as the marketplace dictates.

This, in turn, has resulted in a fundamental reconfiguration of the Federal fossil energy R&D program. As Secretary Edwards described in his opening testimony before you last month, the fossil energy program would focus on the early stages of research and development, on long-term, high-risk research that may have substantial future benefits but is beyond the timeframe or scope of the private sector.

There are no mathematical formulas that define for all cases where public and private sector responsibilities are divided. But perhaps by referring to the typical development path of a new technology, as we have shown on page two of the formal statement, it may be easier to visualize what we mean by "high risk, long term."

As you can see by this chart, the Government's role is concentrated on basic science and applied research where the dominant questions are more technical in nature. These stages of development remain unlikely to attract sufficient private funding because of their generic or high-risk nature or the substantial time required before they return commercial benefits.

Beyond these stages, where market factors begin to play an increasingly important role in process development and commercialization, we believe industry should assume the initiative.

In some technologies, it may be necessary for the Government to continue through "proof of concept" before the risk of a new technology is brought within the scope of industry. This was the case for several coal gasifiers in our past program. Once the technical feasibility of several processes was shown in small scale units—a few tons per day in size—many firms began their own development and commercialization programs.

We have some "proof of concept" projects in this budget—the Grimethorpe pressurized fluidized bed unit and the Mobil M-gasoline pilot plant, for example.

Although no new funding is requested, we have sufficient funds from past years to continue "proof of concept" work on advanced liquefaction techniques at the 6-ton-per-day Wilsonville test unit. We anticipate that each project will provide industry the data it needs to make future development and commercialization decisions.

For some technologies, the private sector may be able to move forward following laboratory and bench-scale research. The dry scrubber applied to high-sulfur coals, for example, began to attract commercial interest once its feasibility was shown using a laboratory-scale furnace. Likewise, preparation techniques for coal-oil mixtures were developed in laboratory experiments, then were moved by private firms directly into commercial practice.

It is difficult, therefore, to apply a rigid definition of the proper Federal role that holds true for all technologies. Yet, one general conclusion can be drawn—in almost all areas, Government research to date has proven most effective when it concentrated on the early stages of development, on basic and applied research and in some cases, on proof of concept.

The $107 million in budget authority requested for the fiscal year 1983 fossil energy program reflects the fact that research of this nature is inherently less expensive than constructing large-scale pilot and demonstration plants. It also recognizes that the need is even greater this year to restrain Federal spending, and in light of overriding economic concerns, not all promising energy concepts can be pursued.

Nearly 50 percent of our budget request relates directly to developing new sources of petroleum or providing a substitute for conventional liquid fuels. This is our highest priority, because liquids remain a primary source of national concern about energy. Technology base research into the liquefaction of coal, the retorting of oil shale, the recovery of additional oil from conventional reservoirs, and the development of technologies that allow coal to displace oil make up the bulk of this priority.

The remainder of our budget request is divided between gaseous fuel technologies and the direct utilization of coal. Included in this gas-related activity is the conversion of coal to a synthetic gas which could be used as a feedstock for liquid fuels or chemicals, or upgraded to pipeline quality, or used in a fuel cell or combined cycle power plant.

The direct utilization priority includes technologies for using coal in a more economical, efficient and environmentally acceptable manner. This involves developing new control systems for cleaning coal before combustion and removing pollutants from the postcombustion gases——

Senator DOMENICI. Could I interrupt for a minute? I know that Senator Ford is going to have time problems today, so I hope you will feel free to interrupt with questions.

I am going to leave for about 5 minutes. I would appreciate it if you would chair and I will be right back.

Mr. MARES. I have about another page in my statement. I could respond to questions, or finish.

Senator FORD [presiding]. You go right ahead.

Mr. MARES. Each of these activities are currently planned to be transferred to the Commerce Department, if Congress agrees. We are proposing to shift one program—mining R&D—back to the Department of the Interior where it would be combined with work already underway to improve the safety and environmental impact of coal extraction.

And there are three activities we are proposing not to continue in 1983. One is the heat engines program, where we believe industry is well-positioned to evolve many of the technology improvements from activities it has underway already—in higher temperature turbines, for example.

The other is magnetohydrodynamics, where the issue is not whether the technology is of marginal or greater benefit, but simply that it is a process that requires a large-scale, expensive "proof of concept" effort.

And the third is the enhanced gas recovery program, where industry activity is also increasing and many of the Federal projects are now reaching logical conclusions.

Finally, Mr. Chairman, we are not reluctant to admit that this budget was forged from a series of hard choices, in which individual program objectives were balanced against overall national priorities. In some cases, we chose to eliminate some programs entirely rather than disperse small amounts of funding across too broad a technological spectrum.

The fact that a technology is not being supported does not mean that past work in it was not useful; instead, it means that when weighed against other priorities and when we considered the other economic incentives now in place, our judgment was that other technical areas were more appropriate recipients of Federal dollars.

Therefore, we ask this committee to judge the funding proposed for the fossil energy program in the context of a broader energy strategy involving less Government spending, regulation and taxation. We believe that, coupled with these other incentives, this budget represents a realistic approach to building a sound knowledge base from which the fossil energy industry can select the technological options it deems most appropriate.

I will be pleased to answer your questions.

[The prepared statement of Mr. Mares follows:]

The Fiscal Year 1983 Budget Request for the Federal Fossil Energy R&D Program

Prepared Statement of

Jan W. Mares
Assistant Secretary
for Fossil Energy

U.S. Department of Energy

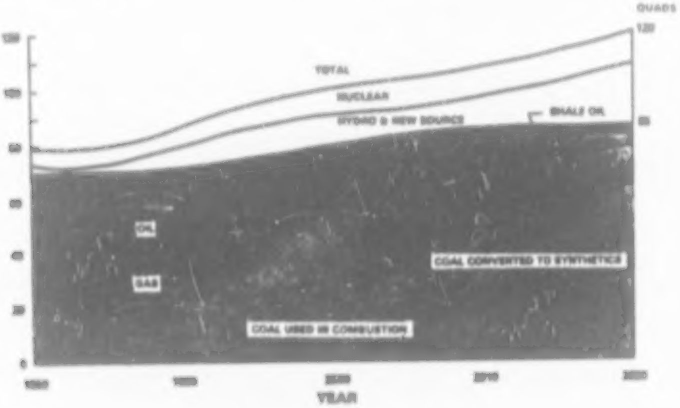
To The

Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
U.S. Senate

March 17, 1982

Mr. Chairman and Members of the Committee:

The portion of the Administration's proposed fiscal year 1983 budget which we will describe today recognizes that fossil fuels — coal, petroleum, and natural gas — are currently the dominant suppliers of energy in the U.S. and will continue to be for decades to come. Today, 90 percent of our energy is derived from these fuels, and forecasts of the nation's energy mix well into the next century (such as the projections of the National Energy Policy Plan shown below) show a continued national reliance on fossil energy, perhaps supplying up to 70 percent of our total energy needs in the year 2020.



NATIONAL ENERGY POLICY PLAN
PROJECTED U.S. ENERGY SOURCES

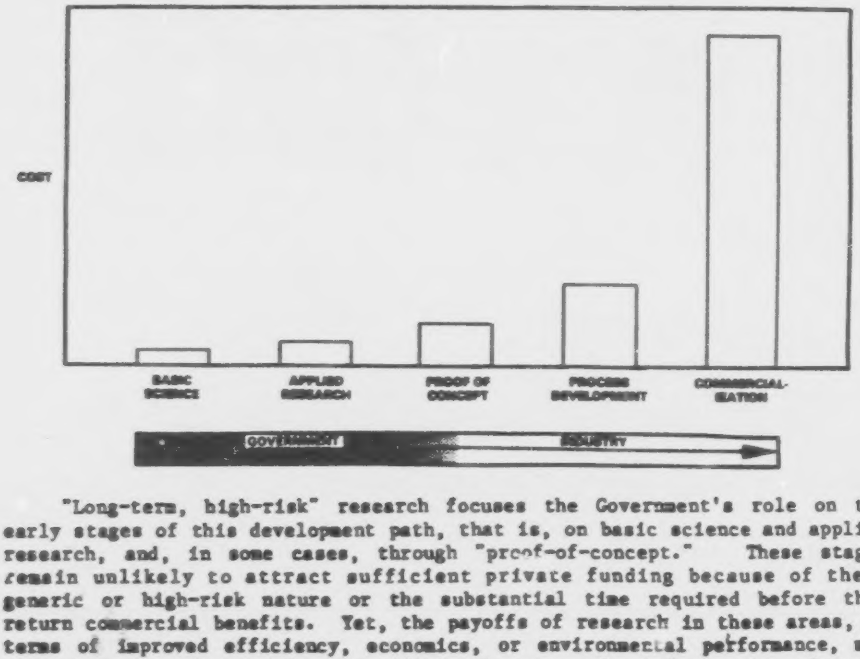
One benefit of this heavy reliance on fossil fuels is the strong technical capability of the industries that produce these fuels and that manufacture the hardware to utilize them. The policy on which this budget is based recognizes that these industries historically have propelled our nation's technological progress in energy. Given today's economic incentives, this sector is well positioned to continue and expand its role in developing and marketing new fossil energy technologies with minimum government help. Government has played an important role, most notably in such areas as coal-oil mixtures, atmospheric fluidized bed combustion, and new synthetic fuel processes, but the market continues to be the ultimate judge as well as the ultimate beneficiary of new energy technology.

Therefore, the proposed budget for fossil energy research and development in FY 1983 continues the process begun by the Administration last year to 1) reshape Federal research and development (R&D) programs to long-term, high-risk activities so they complement today's private sector initiatives, and 2) restore proper dimensions to Federal spending.

The redirection of Federal fossil energy R&D has reduced the FY 1983 funding requirement to $106.9 million, compared to the FY 1982 appropriation of $416.9 million. Within this budget, we have eliminated activities that overstep the proper sphere of Federal Government responsibilities, and we have better targeted and streamlined those generic and technology base R&D activities that remain appropriate for the Federal Government.

THE FOCUS ON "HIGH-RISK, LONG-TERM" CONCEPTS

A central premise of this budget is that the most effective use of direct Federal outlays is through a program focused on long-term, high-risk research that is beyond the time horizons of private companies. We recognize that the description "long-term, high-risk" cannot be defined precisely; however, to describe generally the boundaries of Federal involvement reflected by this term, it may be helpful to visualize the development milestones a new technology typically passes as it moves from laboratory to marketplace. These are displayed on the following chart:



"Long-term, high-risk" research focuses the Government's role on the early stages of this development path, that is, on basic science and applied research, and, in some cases, through "proof-of-concept." These stages remain unlikely to attract sufficient private funding because of their generic or high-risk nature or the substantial time required before they return commercial benefits. Yet, the payoffs of research in these areas, in terms of improved efficiency, economics, or environmental performance, may ultimately be substantial. An additional reason why industry is reluctant to undertake basic research and development is that it cannot exclude competitors from using the results. Therefore, a further justification for Federal involvement in basic research and development is that the information generated is for the public good.

Beyond these early development stages, Government is not well suited to make the market-related judgments that govern many of the decisions. Stable economic and regulatory policies can be more effective in moving new technologies through these final phases of development and into the marketplace than direct government funding.

The diversity of fossil energy technologies required sufficient flexibility in selecting candidates for funding to accomodate such factors as:

- differences among technologies;
- differences among technology developers and users;
- changing market factors and conditions;
- the size, complexity and economic uncertainties of projects being considered; and
- the resource affected.

These factors influence the point at which private firms are willing to risk R&D funds, and where the Government's role should end.

There is no mathematical formula for drawing the line dividing the responsibility of government and industry in developing new fossil energy technologies. For most technologies, there undoubtedly will be an overlap, as evidenced by projects which involve significant co-funding. In some cases, the point at which industry assumes the initiative may not be finally known until government funding is no longer available.

The process we undertook in formulating this budget, therefore, involved balancing projects against a given set of priorities and within the context of the need for fiscal restraint. In some cases, we chose to eliminate some programs entirely rather than disperse small amounts of funding across too broad a technological spectrum. In this way, we have retained a reasonable level of activity in the highest priority programs.

Priorities

In general, we have given highest priority to building the knowledge base so that the Nation can reduce its reliance on conventional sources of petroleum. In FY 1983, nearly 50 percent of our budget request relates directly to developing new sources of petroleum or providing substitutes for conventional liquid fuels. Research into the liquefaction of coal, the retorting of oil shale, the recovery of additional oil from conventional reservoirs, and the development of technologies that allow coal to displace oil make up the bulk of this funding.

The remainder of our budget request is divided between, gaseous fuels and the direct utilization of coal. Included in the gas-related activity is the conversion of coal to a synthetic gas which, in turn, could be used as a feedstock for manufacturing liquid fuels or chemicals or for use in a fuel cell.

The direct utilization priority includes technologies for using coal in a more economical, efficient, and environmentally acceptable manner. This involves the development of various control systems for cleaning coal or removing pollutants from the combustion gases and research into improved combustion concepts.

Throughout this budget, we have also recognized that the Federal Government has traditional responsibilities relating to environmental protection, health and safety. Therefore, a significant portion of our budget emphasizes research intended to mitigate the environmental problems associated with new fossil energy technologies.

Clearly, the Federal Government cannot support research and development on all promising technologies. We have had to make hard choices on which programs to continue and which to deemphasize or eliminate. The fact that a technology is not being supported does not mean that past work in it was not useful; instead, it means that when balanced against other priorities and when considering the incentives now in place for private initiatives, our judgment was that other technical areas were more appropriate recipients of Federal dollars.

INCENTIVES FOR NEW TECHNOLOGIES

Although not specifically part of the budget being discussed today, important aspects of the overall national energy program are the economic, regulatory and tax incentives developed by the Administration to encourage increased production and more economical use of energy. Because they are expected to provide the incentives necessary for increased private sector development of new fossil energy technologies, they form the starting point for a discussion of the Federal program in fossil energy research and development. These incentives can be summarized as follows:

Decontrol of energy prices: On January 28, 1981, the President completed the elimination of Federal price and allocation controls on U.S. oil production and marketing. The drilling industry has responded to the increased economic incentives brought about by decontrol by pushing drilling rates to record levels. In 1981, drilling in the U.S. reached an all-time high, climbing nearly 26 percent over the previous record year of 1980. Oil drilling accounted for the bulk of the increase. While the increased activity in domestic oil fields has not yet revealed another Prudhoe Bay or another East Texas, it has flattened a production trend that had curved downward for nearly a decade. Also, oil price increases have made other energy technologies, including coal combustion, economically attractive in comparison with oil. Regarding natural gas, while we continue to believe that changes to the Natural Gas Policy Act of 1978 are an essential component of a sound energy policy, the President has concluded that asking Congress to accelerate the current schedule of deregulation would overload an already-heavy legislative agenda this year.

Leasing reform: The Federal government owns or controls up to 60 percent of all U.S. energy resources, including up to 80 percent of all known coal reserves in the western U.S. A comprehensive effort to reformulate Federal leasing policies is underway at the U.S. Department of the Interior to guarantee that these energy resources can be explored and produced at a pace consistent with our national energy needs, social and environmental concerns, and the public interest.

Tax incentives: The Economic Recovery Tax Act of 1981 contains several provisions that will assist the private sector in taking a more aggressive role in energy development and production. A 25 percent research and development tax credit is designed to help restore America's technical edge by reducing the after-tax cost of R&D programs and expanding R&D expenditures. This credit may prove to be a successful market alternative to direct government grants for development of the same technologies. The accelerated cost recovery system is expected to stimulate capital investment of all forms. Petroleum production and refining equipment can be depreciated over five years. Some public utility property would get 10-year depreciation; public utility property with useful lives longer than 25 years would be limited to 15-year cost recovery.

Synthetic Fuel Incentives: On February 9, 1982, the President declared the Synthetic Fuels Corporation to be fully operational. This means that more than $14 billion in financial assistance will be available for synthetic fuel facilities. Last fall, the President approved loan and price guarantees for subsidiaries of the TOSCO Corporation and Union Oil, respectively. Each firm is involved in the construction of a commercial-scale oil shale facility. A loan guarantee also was approved for the Great Plains Gasification Associates commercial-scale coal gasification plant. Taken together, these actions are expected to give private companies the assistance they need to begin a new domestic synthetic fuels industry.

THE FY 1983 FOSSIL ENERGY R&D BUDGET

The FY 1983 fossil energy budget proposes new funding for two of the three primary elements which have comprised past budgets. No funding is requested for the Gas program. The FY 1983 budget request is summarized below and compared with the corresponding appropriation in FY 1982 (in millions of dollars):

	FY 1982 Appropriation	FY 1983 Request
Coal	$ 366.8	$ 90.8
Petroleum	40.9	16.1
Gas	9.2	...
Total	$ 416.9	$ 106.9

Since the proposed FY 1983 program involves a major reduction in the scope of fossil energy R&D activities, including a 55 percent cutback in personnel, the Administration will also propose a deferral and redirection of FY 1982 and prior year appropriations to ensure that adequate funds are available for these transition expenses. The Administration will propose deferral of $44.9 million in FY 1982 and prior year appropriations, with the expectation that the deferred amounts would subsequently be used to finance the following transition activities:

- consolidation of the five Energy Technology Centers (ETCs);
- the required reduction-in-force expenses at the ETCs;
- the termination of ETC contracts, where there are termination costs;
- the placing of various federally-owned pilot plants or test facilities associated with the ETCs in a "mothball" status; and
- the disposition of Federally-owned facilities.

The amount proposed for deferral and subsequent reprogramming is based on beginning many of these actions in April, 1982.

COAL

The abundance of U.S. coal — nearly 475 billion tons is the demonstrated reserve base according to the Department's revised estimates released last year -- makes it one of the nation's strategic resources in both our energy and economic future. It has also become increasingly significant as other countries continue to turn toward a coal-rich America as a competitive, long-term and reliable source of energy.

The 1200-percent rise in world oil prices in less than a decade has imposed a substantial burden on the economies of oil-dependent nations including the U.S. But it also has created an unparalleled opportunity for America's coal production and utilization industry. The average fuel price difference between coal and oil delivered to U.S. utilities in 1973 was about $2 per barrel of oil equivalent in favor of coal. As of September, 1981, coal's domestic price advantage over oil had widened to more than $20 per barrel.

These inherent economic advantages, coupled with the recently-enacted tax incentives and the activities of the U.S. Synthetic Fuels Corporation, are expected to stimulate increased private sector development of new coal technologies. Therefore, the Federal program will concentrate on acquiring a better understanding of the fundamental behavior of coal as it is burned directly or converted to synthetic fuels and on improving significantly the current efficiency, economics, and environmental effects of coal use.

The proposed Coal program budget for FY 1983 is $90.8 million, a $276 million decrease from the FY 1982 appropriations. The components of this budget request are as follows:

Mining Research and Development: (FY 1982 Appropriation: $ 10.992 million; FY 1983 Request: $ 1.000 million)

	FY 1983 Request (in millions)
Underground coal mining.................	$ 1.000
Surface coal mining	...

The long-term development of advanced underground coal production systems and techniques has been shifted from primarily a contract effort to a largely in-house research program. The Administration will propose transfer of the DOE Mining R&D program to the Department of the Interior's Bureau of Mines which conducts similar research activities. This year, the necessary project reviews and facility and equipment inventories will be completed with the Bureau. Previous research efforts conducted by private firms under DOE contract will be closed out or phased down except for those proposed for continuation in the course of discussions with DOI.

Activities continued in FY 1983 will assess the technical feasibility of advanced and novel mining concepts and on previously-funded, long-term trials of advanced longwall mining techniques.

Longwall mining, although accounting for only 5 percent of the nation's underground coal production, nevertheless offers the potential for significant improvements in productivity, worker safety, and the capability to mine deep and multiple seams. These improvements will become increasingly important as shallower deposits are exhausted and miners must move deeper underground and face more difficult conditions. The Federal program in FY 1983 will concentrate on determining the forces and loads on key longwall equipment, using both underground trial data and the program's unique Mine Roof Simulator located at the Pittsburgh Energy Technology Center. Studies will also be made on the systems which guide the longwall shear across the coal face in an effort to overcome current control and alignment problems.

In the room-and-pillar area -- the mining technique accounting for 95 percent of the Nation's underground coal production -- the Federal effort will continue assessing means by which advancements in the roof-bolter, miner-bolter, and continuous haulage system can be better integrated.

In past budgets, coal preparation activities were part of the Mining R&D program. In FY 1981, the coal preparation program was combined with the Advanced Environmental Control Technology program under the heading "Control Systems." The coal preparation program would remain within the Control Systems activity in FY 1983 and is not proposed for transfer with the Mining R&D program.

Liquefaction: (FY 1982 Appropriation: $ 98.784 million; FY 1983 Request: $ 26.200 million.)

	FY 1983 Request (in millions)
Direct Hydrogenation	
H-Coal pilot plant	$ ...
Solvent Extraction	
Exxon Donor Solvent pilot plant......	...
Advanced Process Development	
Disposable catalyst	4.200
Process research/technology development........................	9.600
Indirect Liquefaction.................	8.400
Support Studies/Eng. Evaluations	
Environ. studies & other support	4.000

Liquids remain a primary source of national concern about energy. Although significant potential exists for discovering new sources of conventional petroleum or increasing production from known oil reservoirs, the magnitude and geographical diversity of the nation's coal deposits makes it highly likely, and perhaps necessary, that this resource eventually will be used to increase the supply of liquid fuels. Today, several commercial projects that would convert coal to liquid fuels are being considered by the U.S. Synthetic Fuels Corporation. Most would rely on the "indirect" liquefaction process, where the coal is first gasified, then the gases catalytically recombined to form liquids.

Direct liquefaction — converting coal to liquids without the initial gasification step — offers the potential for improved efficiencies and lower costs. Completion of the government's programs at the 200-ton per day H-Coal and the 250-ton per day Exxon Donor Solvent direct liquefaction pilot plants in FY 1982 will provide a sound technology base for continued development and scale-up of these processes for commercial use by the private sector.

The focus of FY 1983 activities will be on exploring new concepts offering significant improvements in efficiency and economics compared to the H-Coal and Exxon Donor Solvent processes. Information learned from these activities could form the basis for new generations of synthetic fuel technologies in the 1990s and beyond. Much of the Federal direct liquefaction program will concentrate on advanced process development to attain higher thermal efficiencies by reducing the amount of steam, oxygen and/or hydrogen required in the conversion process. One way to do this is by improving the effectiveness of catalysts and minimizing the dependence on high temperatures to break apart the coal structure. By developing cost-effective ways to use these catalysts, the reactivity of the feed coal can be controlled more precisely and undesirable trade-offs in plant design and operating efficiency can be avoided. Improved operating efficiency and better yields of fuel products could be achieved by future plants as a result of this research.

Another approach being pursued in FY 1983 is to separate the step in which coal is dissolved from the step in which the coal extract is upgraded to a higher-quality liquid -- an innovative technique called "Integrated Two-Stage Liquefaction." Bench-scale tests have shown that product yields can be increased by 25 percent over the direct liquefaction processes now at the pilot scale with higher quality liquids produced and less hydrogen being consumed. One of the major efforts in this activity will be to investigate a low-temperature second step that could prolong catalyst life while improving the recycle solvent needed for the dissolving step and to transport hydrogen to the coal extract.

No new funding is provided in FY 1983 for the Wilsonville, Ala., liquefaction facility, a 6 ton-per-day unit owned and operated by the Electric Power Research Institute (EPRI) and a subsidiary of the Southern Company. Sufficient funds, however, are expected to be available from FY 1982, to continue long-range liquefaction research at the facility. DOE funds will be supplemented by funding from EPRI during 1983.

In the indirect liquefaction area, a combination of laboratory and bench-scale efforts will concentrate on new methods of converting the carbon monoxide and hydrogen from coal gasifiers into alcohols or liquid hydrocarbons. A broad-based catalyst and process R&D program is now in place which could result in significant advances in the production of high quality gasoline and/or middle distillates with yields 20-30 percent higher than those of conventional methods. Testing will also be done on new reactor designs that enable closer control of the reaction temperature and more effective recovery of the heat released by the reaction. Research on these new concepts could lead to cost savings of up to 40 percent compared to existing indirect technology.

Transition to the FY 1983 funding level will require eliminating the La Porte, Tex., liquid phase synthesis unit. This facility would have tested alternative methods for producing alcohols and liquid hydrocarbons from gas typical of that from advanced coal gasifiers. Termination of this activity is an example of the judgments necessary when technologies with varying degrees of potential were balanced against the need to limit Federal spending. Given industry's technical understanding of this technology and the obvious economic incentives which would accrue to firms that perfect commercial processes, we believe there are adequate incentives for private industry to continue to develop this process. Our judgment was that more significant benefits could be obtained by investing Federal funds in the development of more effective catalysts and other process improvements.

Also in the indirect liquefaction activity, the internationally sponsored 100 barrel-per-day methanol-to-gasoline (M-Gasoline) pilot plant will be completed in the Federal Republic of Germany in FY 1982. In FY 1983, DOE will collect data on the effectiveness of the advanced "fluidizing" technique employed by the plant to improve temperature control and the effectiveness of the catalyst. Involvement of both the German government and industry and the high probability of royalty payments exceeding the government's investment in the project are the major reasons for proposing to complete this project.

Support studies and engineering evaluations will be conducted to provide independent technical status reviews, engineering assessments, evaluations of ancillary processes (such as hydrogen generation), and environmental and toxicology R&D and coordination.

To achieve a smooth transition from the FY 1982 program to the FY 1983 budget levels, the Administration intends to propose a redirection of FY 1982 appropriations to provide for the orderly termination of selected activities and to provide a source of financing for redirecting program activities. The specific transition actions proposed for FY 1982 are:

- Terminate Federally-funded operations at the H-Coal pilot plant in November 1982 rather than in December 1982 if an agreement can be reached to transfer the plant to the industrial partners; otherwise terminate operations in June 1982 rather than in July 1982 and begin dismantling the plant. Either action would permit deferral of $3 million to be used in subsequent reprogramming proposals;
- Terminate government funding of the Exxon Donor Solvent pilot plant operations on July 1, 1982. This action will permit the deferral of $3.1 million for subsequent reprogramming;
- Terminate the liquid phase methanol process development unit operations in mid April, 1982, permitting $2.225 million to be used for later reprogramming;
- Terminate the SRC-I demonstration plant project design following the expected delivery of the project baseline cost and schedule to Congress in May. Disposition of funds remaining from the $129.6 million deferred from FY 1981 will be addressed by a subsequent Administration proposal to Congress.

Surface Coal Gasification: (FY 1982 Appropriation: $ 53.088 million; FY 1983 Request: $ 10.500 million)

	FY 1983 Request (in millions)
Advanced Process Development	$ 4.250
Systems Engineering Concepts	
Gasifier systems	...
Equipment/instrumentation	3.000
Environmental and Engineering Analyses	
Environmental studies	3.250
Engineering analyses/support	...

To ensure that new concepts for converting coal into synthetic gas continue to enter the development cycle and that problems generic to many gasification processes are overcome, the Administration has established three primary objectives for its surface coal gasification program:

(1) explore and determine the applicability of alternative chemical processing principles and fluid dynamics as possible ways to improve the overall efficiencies and economics of coal gasification;

(2) develop new and promising approaches through the "proof-of-concept" stage for medium-Btu gas that could lower product costs by at least 20 percent as compared to first-generation processes. Medium Btu gas would be emphasized because of its wide diversity of applications including industrial and electric utility uses, conversion to a variety of liquid fuels as well as to synthetic natural gas, or for use as a feedstock for manufacturing chemicals; and

(3) compile a data base on environmental, worker health, and occupational safety performance of commercial and pilot-scale gasification systems and, based on the results, develop effluent treatment concepts capable of meeting existing emission limits as well as workplace safety and health requirements.

A comprehensive technology data base for new gasifier concepts and systems will be established under the advanced process development budget category. Included in the data will be information on process fundamentals, results of new waste water treatment techniques, computer modeling of gasification reactors, and the collection of basic information on all phases of coal gasification, from coal feed through gas cleanup and effluent disposal. The data will include test results from small entrained and fluidized bed reactor systems and could offer the basis for significant long-term improvements over conventional fixed bed gasifiers such as the dry-ash Lurgi. Particularly important will be data which could give new insights into why some coals cake during gasification as well as a more fundamental understanding and control of sintering, clinkering, and slag formation in various gasification systems. Basic experiments will also be conducted on waste water treatment processes and other environmental control systems associated with coal gasification processes.

Operating a coal gasification facility reliably, economically, and efficiently depends substantially on the availability of suitable equipment, instrumentation and control systems, as well as proper materials and fabrication methods. Previous pilot and smaller-scale operations have shown some inherent drawbacks in relying on equipment and technology from other industrial processes, due primarily to the unique combination of high temperature, high pressure, and the erosive and corrosive environments within coal gasification systems. The focus of the systems engineering concepts activity in FY 1983, therefore, will be to investigate new ways to measure key conditions encountered in a gasification facility, such as solids/gas flow, high temperatures, stream composition, erosion and corrosion in process lines, etc. This work will be performed in laboratory test loops. The effects of slag additives on gasifier refractory life will also be assessed in specially designed laboratory equipment, and generic studies will continue on metal coatings and claddings that can withstand the effects of hot coal gases.

No funding has been requested in FY 1983 for developing individual gasifier systems. Several advanced gasifiers have emerged from the prior Federal program, such as the Westinghouse fluidized bed gasifier, U-Gas, and the Exxon catalytic gasification system. The first commercial-size project, the Great Plains Gasification plant, is now moving forward, and knowledge gained from this facility as well as directed bench scale studies will be sufficient to optimize these new technologies. (The Government's monitoring of the Great Plains loan guarantee in FY 1983 will use funds left unspent from the Alternative Fuels administrative account. The anticipated FY 1983 requirement for administering the loan guarantee is $2.4 million.)

Emphasis was increased in FY 1982 on attaining a better understanding of the environmental aspects of converting coal into synthetic gas, and in FY 1983 that emphasis will continue. As part of the environmental studies effort, a gasification cleanup system will be operated under transient conditions and studies will be made to determine the efficiency losses associated with operating a cleanup system under actual end-use conditions. This is expected to lead to more effective designs of environmental control equipment.

As in the liquefaction program, several actions will be required in FY 1982 to ensure a smooth transition into the reduced program proposed for FY 1983. Specifically, these actions are:

- Terminate the Bi-Gas pilot plant operations beginning in mid April, 1982, and place the facility in a "mothball" status. This will permit deferral of $2.5 million to be used for subsequent reprogramming;

- Terminate fixed-bed gasifier activities at the Morgantown and Grand Forks Energy Technology Centers in mid April, 1982, placing the gasifiers in a "mothball" status, thereby freeing $500,000 for use for subsequent reprogramming;

- Terminate the peat gasification work being performed at the HYGAS pilot plant and place the facility in a "protected stand-by/mothball" status, permitting $100,000 to be subsequently reprogrammed;

- Terminate the agglomerating fluidized bed development effort at the Westinghouse process development unit facility in mid April, 1982, and place the facility in a "mothball" status. This action will permit deferral of $2.9 million for later reprogramming; and

- Terminate the atmospheric entrained-bed slagging gasifier (Combustion Engineering) pilot plant program in mid April, 1982, and place the facility in "mothball" status. This action will permit the deferral of $200,000 to be used in a subsequent reprogramming proposal.

Underground Coal Gasification: (FY 1982 Appropriation: $ 8.256 million; FY 1983 Request: $ 0.700 million)

	FY 1983 Request (in millions)
Gasification Technology Development	$ ...
Environmental and Advanced Research	.700

Techniques that gasify coal underground are particularly applicable to coal seams that are too deep and thick or that are pitched at too great an angle for effective mining. Synthetic gas produced from this technique can be converted into transportation fuels such as methanol and gasoline, used as a fuel for electric power generation or as a feedstock for chemical manufacturing, upgraded to synthetic natural gas, or at some specific sites, as a generator of CO_2 for enhanced oil recovery and hydrogen for refinery use or shale oil upgrading.

In FY 1982, the concept of gasifying steeply dipping beds and producing a medium-Btu gas was proven at a site in Wyoming, and large block tests from a Washington coal seam will soon be completed to determine cavity growth and coal response. As a result, the need for futher Federal support of technology development has been diminished, and further technology development is expected to be undertaken by industry. Consequently, the Federal effort will concentrate on legally-mandated environmental monitoring and research at past test sites.

Advanced Research and Technology Development: (FY 1982 Appropriation: $56.256 million; FY 1983 Request: $19.800 million)

	FY 1983 Request (in millions)
Processes	$ 5.000
Direct Utilization	4.200
Materials & Components	
Materials	3.940
Components	.860
Program Development & Coordination	
Budget & administration (construction)	2.800
Environmental activities	2.000
Planning & policy	1.000
University coal research	...

The Advanced Research and Technology Development (AR&TD) program is aimed at extending the fundamental scientific and engineering knowledge base for fossil energy. In this activity, a better understanding is gained of the fundamental mechanisms of converting coal to gas and liquid fuels or burning it directly. Also included are generic studies of materials and components which may have application across the spectrum of fossil energy use. In conducting these activities, scientists will hopefully develop ideas for new processes and possible technical breakthroughs in coal conversion and utilization.

The AR&TD program differs from other activities in the Coal program in that it addresses a broader technological spectrum than research carried out under the coal liquefaction, gasification or combustion categories, for example. Yet, projects supported by the AR&TD budget remain closely connected to long-range Fossil Energy objectives, thus distinguishing the program from the more general mandate of the agency's Office of Energy Research.

Out of this activity, for example, has come a better understanding of coal chemistry, the structure of coal, and the role mineral matter plays in coal conversion. Innovative approaches for upgrading low or medium Btu gas to methane have emerged from AR&TD research, as did the pioneering work establishing the early viability of coal-water mixture combustion. The diversity of the research is reflected by the fact that this activity has also included studies of the mechanisms of soot formation from the burning of synthetic fuels, the identification of critical composition and microstructural aspects of ceramics, and the exploration of new approaches to recovering useable heat from effluent gas streams.

In FY 1983, the processes budget category will include work in both liquefaction and gasification. Small scale research in the liquefaction area will include studies of the generic mechanisms of coal liquefaction, in addition to research on advanced catalysts. Other projects will investigate the effects of mineral matter on the kinetics of coal liquefaction. The gasification activity, likewise, includes pioneering research across a broad technical front involving kinetics, thermodynamics, catalytic mechanisms, modeling, hydrogasification, pyrolysis, fluidization studies, acid gas removal, hot gas cleanup, gas separation, conversion studies, and novel concepts for generating synthetic gas by reaction with steam, air, and oxygen. These activities will generate important data which will be used to construct a sound fundamental synthetic fuels technology base

The direct utilization effort will expand the technology base required for the increased use of coal including low-rank coals, chars, beneficiated coals, and coal-liquid mixtures. Approximately 50 individual efforts will address areas such as fuel injections and preignition processes, flame chemistry, pollutant formation and control, fouling and slagging, and modeling and scaling techniques. Emphasis will be given in FY 1983 to developing a data base required for retrofitting oil and gas designed equipment for coal firing and expanding coal firing options in industrial process heat applications.

The materials activity will provide the data for future decisions on structural materials in fossil energy conversion systems and could lead to materials with higher efficiency and greater longevity. The program will attempt to gain a better understanding of the basic phenomena involved as materials degrade in fossil energy systems.

The components program will continue fundamental research into the peripheral and support equipment involved in fossil energy utilization. Specific research will focus on advances in analytical models of flow patterns when solids, liquids and gas are mixed (called "three phase flow"), the development of a thermodynamic base for heat exchangers and the development of scaling parameters for multi-phase flow systems.

The funding request for budget and administration includes $1 million for incremental funding of the construction and initial equipping and operation of a surface water containment and waste water treatment facility at the Pittsburgh Energy Technology Center so that current violations of waste discharge regulations can be corrected. The remaining $1.8 million is for a waste water treatment facility at the Morgantown Energy Technology Center and for other general plant projects at the Energy Technology Centers. The Department is currently planning a major consolidation of the Fossil Energy field structure, aimed at reducing the number of Energy Technology Centers from five to perhaps one or two. If, as a result of these actions, these general plant projects are not required, an amendment will be forwarded to the Congress.

Funding for environmental activities will finance policy development, R&D assessment and compliance overview in the areas of environment, safety, and health. This activity will ensure that fossil energy projects are conducted in compliance with relevant laws and regulations, such as the National Environmental Policy Act, the Clean Air Act, the Occupational Safety and Health Act, and others. By involving environmental, health and safety concerns early in the technology programs, the future acceptability of new process concepts emerging from the Fossil Energy program can be assured.

Planning and policy funding will be used to conduct contract studies and data collection on a variety of fossil energy related topics which will be valuable for planning future research and development activities. Administrative support for the Fossil Energy program is also provided under this budget category.

No funds have been earmarked specifically for university activities in FY 1983 since government-supported university projects can be found throughout the Fossil Energy program and in other Departmental programs.

Combustion: (FY 1982 Appropriation: $ 30.544 million; FY 1983 Budget Request: $6.500 million)

	FY 1983 Request (in millions)
Atmospheric Fluidized Bed Combustion	$ ...
Pressurized Fluidized Bed Combustion	
IEA Grimethorpe PFB	2.500
PFB Technology Base Support	2.000
Alternative Fuel Utilization	
Alternate fuel mixtures	2.000

Industry has now assumed the lead in developing and marketing several new coal combustion techniques, including atmospheric fluidized bed combustion systems. At least 35 atmospheric fluidized bed boilers are now in operation, under construction, or being designed, and at least 10 boiler manufacturers are now developing or marketing commercial versions of this new combustion technology.

As a result, the Federal combustion research program in FY 1983 will concentrate on technology base research for pressurized fluidized bed (PFB) combustion and support for the international experimental pressurized fluidized bed facility at Grimethorpe, England. The pressurized fluidized bed approach represents the next generation of advanced coal combustors. The International Energy Agency's Grimethorpe program will focus on evaluating combustor performance, coal feeding, ash removal, and gas stream cleanup. This project has special significance because of the international cooperation it entails with Great Britain and the Federal Republic of Germany. Construction of the unit has been completed and the first test runs have taken place. The $2.5 million requested in FY 1983, along with funding from our international partners, is expected to be sufficient to develop a sound data base for the pressurized fluidized bed combustor, the heart of this advanced combustion concept. We will also continue to assist in efforts to interest other governments or industries in sponsoring the follow-on phase of the project which would include modifying the facility to incorporate a gas turbine.

While no funding is requested for the Wood-Ridge, NJ, pressurized fluidized bed facility, construction is continuing in FY 1982 and negotiations will be undertaken to reduce Federal involvement while still completing the construction and operation of this facility.

The PFB technology base support will concentrate on the basics of fluidized bed combustion at pressures of up to 20 atmospheres. Corrosion and erosion of various boiler and gas turbine materials will be studied. Scale-up laws will be better defined. An investigation of the effects of tube bundle solidity on heat transfer and studies of the combustion characteristics of coal-based mixtures and low rank coals will be conducted.

Industry has also assumed the initiative in commercializing coal-oil mixtures, in some cases using data generated in past government research programs. The alternative fuel utilization program, therefore, will focus on higher-risk coal-based slurry fuels, such as coal-water and coal-water-alcohol. Coal-water mixtures, particularly, have attracted substantial interest recently because of their potential for replacing 100 percent of the oil burned in a utility or industrial oil-designed boiler. Mixtures of up to 70 percent coal and 30 percent water have been shown to have storage, handling, and transportation characteristics compatible with conventional oil-handling equipment with only modest modifications. The Department recently selected two firms to perform a series of tasks intended to build a sound data base for industry to make future commercial decisions on coal-water mixtures. If this data, coupled with information developed by an on-going in-house research program, is successful in stimulating industry to move ahead on its own, as much as 3 million barrels per day of oil could be displaced in major fuel burning installations across this country.

Changes in the FY 1982 Combustion Systems program are also being proposed to provide a source of funds for the transition from FY 1982 to FY 1983. Specifically, these proposed actions are:

- o Renegotiate the contract for the PFB Combined Cycle pilot plant project at Wood-Ridge, NJ, to increase private industry funding for construction completion and operations, thereby permitting $6 million in Federal funds to be subsequently reprogrammed;
- o Terminate the PFB alternate turbine test activities, permitting the deferral of $700,000 for later reprogramming;
- o Terminate the advanced combustion technology program, which would permit deferral of $1.056 million for subsequent reprogramming.

Control Technology and Coal Preparation: (FY 1982 Appropriation: $ 25.152 million; FY 1983 Request: $ 8.600 million)

	FY 1983 Request in millions
Coal Preparation & Analysis	$ 2.000
Flue Gas Cleanup	
Combined flue gas cleanup	3.000
Gas Stream Cleanup	
Turbine cleanup systems	1.500
Fuel cell cleanup systems	1.200
Process modification technology	.500
Cleanup Base Technology	.400

The economics of producing energy from coal are penalized by sulfur and ash-forming impurities in the coal. Added costs are incurred in transportation, capital investment, operation and maintenance, impaired plant reliability, environmental control, and waste disposal. Today's commercial coal users are limited in their methods of removing these impurities. Significant benefits could be gained if future plant operators could make tradeoffs between a wider variety of coal preparation methods applied before coal is shipped, and improved combustion gas clean-up systems installed at the plant site. To assist industry, therefore, the Federal R&D program has been restructured to treat the entire coal cleaning process -- from mine to stack — as successive, interdependent steps.

The first step in this "control systems" approach is to remove sulfur and ash from coal by precombustion cleaning, or coal preparation. The more of these impurities that can be removed, the greater the potential savings in transportation, power generation, and environmental costs. Many U.S. coals resist extensive cleaning unless they are ground considerably finer than present day technology allows. Our goal is to develop techniques to grind coal as much as 60 times finer than is common in today's coal preparation plants. Once this is done, fine coal physical cleaning can remove the bulk of ash-forming minerals and the mineral sulfur or iron pyrite in coal. An even higher quality product can be obtained by extracting most of the remaining organic sulfur (which is chemically bound to the coal structure) and residual mineral matter by chemical cleaning.

The Federal program addresses these challenges. Our efforts are intended to aid the private sector in developing methods to clean even inferior U.S. coals to qualities approaching fuel oil. Our research to date gives us strong encouragement that this can be done. If we establish the necessary firm technology base and validate cost-effectiveness through creditable "proof-of-concept" engineering tests, the private sector will move ahead to full commercial development. Two advanced chemical methods, microwave desulfurization and fused salt treatment, appear particularly promising and development of both will continue in FY 1983.

With industry assuming much of the initiative in moving new flue gas desulfurization technologies — or "scrubbers" — into commercial practice, the Federal program is now focusing on a significantly more advanced generation of flue gas cleanup systems. Emphasis is being placed on electrochemical or chemical systems which simultaneously remove both NO_x and SO_2 in a single reaction, rather than in a series of separate steps as is the practice today. The FY 1983 budget would continue research on electron beam irradiation and advanced chemical processes begun in 1981. University-level testing of advanced particulate control will also continue.

To improve the prospects for new combined cycle generating systems powered by synthetic gas from coal or the exhaust from a coal-fired pressurized fluidized bed combustor, government research will also continue in turbine cleanup systems. Efforts in FY 1983 will continue projects begun in prior years to improve methods for removing alkali and particulate impurities from hot (up to 2400 degrees F), high pressure (500 psi) gas streams before they can damage conversion cycle equipment and/or violate environmental emissions standards. "Proof of concept" tests will be conducted under actual pressurized fluidized bed combustor conditions using a variety of coals.

The aerodynamics/materials problems associated with high-speed turbomachinery do not exist when coal gasifiers are linked to the molten carbonate fuel cell. The fuel cell, however, is susceptible to electrode poisoning and/or deterioration, and electrolyte contamination. Therefore, the Federal control systems program also includes a fuel cell cleanup systems activity to quantify the limits of contaminants acceptable to the molten carbonate fuel cell, to evaluate the applicability of state-of-the-art gasifier cleanup systems to fuel cells, to determine the incentives for developing high temperature fuel cell cleanup processes, and to build the technology base so that industry can develop the most appropriate cleanup systems.

An alternative to flue gas cleanup or the use of separate cleanup equipment for hot gas cleanup may be to modify the combustion or gasification process itself to either suppress pollutant formation or remove the pollutant as it is formed in the gas. This approach is being pursued under the process modification technology budget category. To determine the most desirable approaches, a better understanding is needed of the mechanisms by which pollutants are formed along with their chemical make-up. Once specific control techniques are conceived, they must undergo technical and economic feasibility tests to determine the requirements for further development. In FY 1983, an assessment of the most desirable NO_x control techniques, centering on combustion modification and catalytic combustion, will be completed. Guidelines for selecting physical/chemical techniques for SO_2, alkalies, trace metals, and hydrocarbon capture or destruction will also be determined.

The cleanup base technology activity has been revised to focus on combustion system waste management and characterization, and will emphasize two projects: waste sampling and characterization, and assessments of the Resource Conservation and Recovery Act and other environmental regulation impacts on coal-fired utilities.

Fuel Cells: (FY 1982 Appropriation: $34.464 million; FY 1983 Request: $ 9.500 million)

	FY 1983 Request (in millions)
Phosphoric Acid Systems Development.........	$ 5.000
Molten Carbonate Systems Development........	3.500
Advanced Concepts...........................	1.000

Because they generate electricity and heat by electrochemical reactions, and not by combustion, fuel cells have particularly attractive environmental, efficiency, and siting flexibility benefits. Applications range from electric utility multi-megawatt power plants to on-site multi-kilowatt cogenerating systems to power for transportation and defense facilities.

During FY 1982, power will be produced from the nation's first prototype utility fuel cell, the 4.8 megawatt phosphoric acid demonstrator power plant in New York City, and development will continue on critical technology components and subsystems required to improve system life, power density, and costs. Also, the first field tests of the 40-kilowatt on-site power plants will begin, and the first 40-kilowatt systems will be delivered under a joint DOE/Gas Research Institute field test program. The FY 1983 phosphoric acid systems development program will complete the retrofit of the fuel cell stack for the 4.8 megawatt power plant and will provide funding for completion of development activities for the electric utility technology development program. Phosphoric acid fuel cell technology has reached the stage where the private sector can now begin assuming responsibility for manufacturing and marketing the technology.

Second generation molten carbonate fuel cell systems development will also continue in FY 1983 with emphasis continuing to be placed on critical technical issues. While both phosphoric acid and molten carbonate fuel cells can be linked to a coal gasifier, a particular advantage of the molten carbonate system is that it can be combined with a steam or a gas turbine thereby boosting the system's overall efficiency. In FY 1983 a selected stack of sub-scale size molten carbonate fuel cells will be operated, a commercial-type cell will complete long-duration test operations totaling 10,000 hours, and an evaluation will be undertaken of the capability of the system to operate on coal-derived gas.

The advanced concepts program focuses on the solid oxide fuel cell, a design concept which offers the advantages of solid state stability and can be more easily manufactured. The funding requested in FY 1983 would complete a 5,000 hour test of an advanced design cell, permit preliminary design of 5-10 kilowatt stack module, continue follow-up analysis and development advanced concepts for mobile applications, and complete the initial R&D requirement for solid oxide fuel cell configurations.

Heat Engines: (FY 1982 Appropriation: $ 15.408 million; FY 1983 Request: $ 0)

The Heat Engines program in prior years contained a variety of associated activities, including the high temperature gas turbine cooling and low NOx combustor technology; gas turbine and diesel engine materials and coating development, externally fired heat engine cycle work, and feasibility testing of diesel engines and gas turbines on coal-derived liquids and coal-water mixtures.

These activities are approaching the "proof of concept" point where the private sector is provided the option to continue further development. Many of the technology improvements supported by this program could eventually be undertaken by manufacturers as they make advances in existing technologies. Therefore, no funds have been requested in FY 1983 for continuing this program.

In conjunction with the planned termination of this program, $8.736 million in FY 1982 funds is being proposed for deferral. This funding originally was intended for Phase III of the High Temperature Turbine Technology Program.

Magnetohydrodynamics (FY 1982 Appropriation: $21.840 million; FY 1983 Request: $ 0)

The Administration also proposes to phase out the overall magnetohydrodyamics (MHD) program beginning in FY 1982, and no funds are requested for FY 1983. MHD is a technology that requires a large-scale "proof of concept" demonstration (in the range of a 250 to 300 thermal megawatt facility) with attendant development costs approaching perhaps $500 million. In light of budgetary constraints, the multiple energy conversion technologies presently being pursued by both private industry and the Fossil Energy program, and the relatively high development costs and relative expected benefits of MHD, the Administration cannot support continuation of funding for this technology.

Under this budget proposal, termination actions would begin in April 1982. The advanced power train development program would be brought to an orderly conclusion during FY 1982 and serve as the focal point for consolidating the key technical data which may subsequently be of use to government and private industry. The Component Development and Integration Facility in Butte, Montana, and the Coal-Fired Flow Facility in Tullahoma, Tennessee, would be placed in a "mothball" status. By beginning these actions in April, sufficient funds would be available to fund termination liabilities and facility mothball costs, plus defer an additional $1.9 million for subsequent reprogramming.

PETROLEUM

The target for recovering new supplies of oil in the U.S. is extremely large. Nearly 450 billion barrels of oil have been discovered, yet only one-quarter of that has been produced. Best estimates are that 28 billion barrels of reserves remain to be produced through conventional recovery methods. To date, the contribution of enhanced oil recovery has been roughly 400,000 barrels per day, nearly three-fourths of which is produced by steam injection in heavy oil reservoirs. Over the longer-term, however, enhanced oil recovery is expected to increase, particularly with the incentive of decontrolled oil prices. The focus of the Federal research effort, therefore, is to concentrate on more generic technology base research, leaving to industry the task of bringing technology to commercial readiness.

Oil shale is another potential source of unconventional petroleum supplies. Several retorting processes are considered commercially feasible today. The companies involved in oil shale projects have the financial and technology resources to commercialize existing and new technologies. Therefore, the government's efforts will concentrate on generic research on the chemistry and physics of western oil shale processing and on explosive fracturing. Work will also continue on the potential environmental effects of oil shale development and their mitigation.

Enhanced Oil Recovery (EOR): (FY 1982 Appropriations: $ 16.176 million; FY 1983 Request: $5.8 million)

	FY 1983 Request (in millions)
Heavy Oil	$ 1.9
Light Oil	3.9
Tar Sands	...

Because private industry can be expected to continue to improve existing EOR proceses and eventually to develop new concepts in response to oil price increases, the Federal EOR program is now directing its primary emphasis on long-range, high-risk technology base research that attract limited private capital.

The heavy oil program will continue to concentrate on improving the recovery efficiency of thermal processes. If recovery efficiency can be improved from the current 50 percent to a level of 60 percent, an estimated two to three billion barrels of oil could be added to the nation's recoverable reserves. Similarly, if heat losses can be reduced in wellbores, thereby permitting steam to be piped to deeper reservoirs, domestic reserves could be boosted by one to two billion barrels. In FY 1982, the long-term test of the downhole steam generator, part of Project Deepsteam, will be completed. The significant private sector interest in this concept has eliminated the need for additional development by the Federal government. The FY 1983 funding request, therefore, provides for continued research into the behavior and mechanisms of heavy oil recovery. Research would continue to investigate flow properties, the kinetics of in situ combustion, and steam mobility control. Evaluations of chemical additives with steam and studies of foams and other ancillary materials for improving sweep efficiency, mobility control, and environmental effects would also continue.

The light oil funding request, likewise, would continue fundamental research into the behavior and mechanisms of light oil EOR processes, including chemical and miscible gas flooding. Research will be conducted into mobility control, the interfacial tension effects between oil, chemical, and water molecules, the stability of chemicals at the elevated temperatures and increased brine salinity encountered underground, basic studies on how oil drops coalesce, and in several other areas. The research will be conducted in-house and at several universities, and several ongoing, previously funded, cost-shared field tests will continue to be monitored.

The private sector has adequate incentive to continue development of tar sands in view of the current state of the technology, the decontrol of oil prices, the existence of the Synthetic Fuels Corporation, and recent regulatory changes allowing tar sand leasing on Federal lands. Therefore, no further federal R&D is warranted and no funding has been requested for FY 1983. Activities related to the in situ tar sand experiments at Vernal, Utah would be phased down and concluded in FY 1982, permitting the deferral of $500,000 to be used for subsequent reprogramming.

Advanced Process Technology: (FY 1982 Appropriation: $ 4.032 million; FY 1983 Request: $ 3.000 million)

	FY 1983 Request (in millions)
Advanced Exploratory Research	$ 3.0

A variety of generic and fundamental supporting research activities related to oil, gas, oil shale, and tar sand resources are conducted under this budget category. For example, a portion of the Advanced Exploratory Research budget will be continued on the use of microbes for enhanced oil recovery. Researchers will attempt to identify and isolate microbial strains that can survive and generate through a biological process, surfactants, polymers, emulsifiers and other chemicals under reservoir conditions. Research will also be done on advanced recovery methods using vacuum extraction, superheated water, and novel solvent products. Studies to remove mutagenic, carcinogenic, and other toxic products from heavy crudes, tar sand bitumen, and shale oil will be pursued, as well as supporting research into the stability, degradation mechanisms, and rheology of synthetic fuels. Analytical support will also be provided to the Strategic Petroleum Reserve Office.

A variety of "cross-cutting" research applicable to all petroleum-related programs will also be conducted. This will include efforts dealing with rock mechanics, improved analytical methodology, and instrumentation for studying the physical and chemical properties of fossil derived liquids and for aiding in the extraction of gas from tight reservoirs. Another aspect of this program involves fundamental research into the existence and magnitude of abiogenetic methane and methane hydrates, as well the evaluation of the potential for recovering these unconventional resources.

Oil Shale: (FY 1982 Appropriations: $19.152 million; FY 1983 Request: $6.300 million)

	FY 1983 Request (in millions)
Technology Base..............	$ 3.700
Environmental Mitigation.....	2.600

Oil shale technology is now making the transition from laboratory and pilot scale testing to the first commercial applications. Initial private sector activities are concentrated in the western U.S. where the richest reserves of oil shale lie. Substantial lower quality resources also occur in the eastern states. Together, the oil potential represented by U.S. oil shale deposits is much greater than all of the oil reserves of the Middle East.

As privately-initiated projects continue to move forward, the Federal program will limit its oil shale technology base activities to generic research on the chemistry and physics of western oil shale processing and on explosive fracturing. If a better understanding can be developed in these areas, future oil shale processes could achieve significantly higher conversion efficiencies and fracturing could be done with greater predictability. Examples of this work include the development and application of improved X-Ray, nuclear magnetic resonance, and other analytical techniques for application to shale oil products and chemical reactions. Funding for previous development and demonstration projects, conducted under cost-sharing contracts, will be completed in FY 1982, and the FY 1983 budget level represents the winding down of related evaluation activities, phase out of further technology base research on Eastern shales, and postponement of R&D on specific process concepts.

While the first shale oil production plants will be able to comply with current environmental standards using conventional technology, the long-term accumulation of such facilities in environmentally-sensitive areas could require improvements in environmental control technologies. Therefore, a prime focus of the Government's research program will deal with environmental mitigation. The proposed budget would permit a study of the relationship between process conditions and the efficacy of sulfur removal as well as the chemistry of formation and control of other air emissions. Also, laboratory experiments would be continued to develop solid waste management strategies, including the preparation of an integrated solid waste management plan. Studies would also continue on potential water purification techniques, and a waste pile stabilization plan would be completed for the government-owned Anvil Points facility in Colorado.

Two revisions are also proposed in the FY 1982 budget. Government participation would be concluded in the Geokinetics oil shale project cooperative agreement, thereby allowing approximately $1.8 million to be proposed for deferral and subsequent reprogramming, and the solicitation for proposals involving innovative eastern shale conversion concepts would be cancelled, permitting $624,000 to be used as a source of funds for subsequent reprogramming.

GAS

Natural gas currently supplies about one quarter of the total energy consumed in the U.S. While the annual addition of gas reserves from new discoveries has been less than withdrawals from proved reserves for almost the last decade, the difference between additions and withdrawals has decreased steadily as exploration has picked up with phased energy price decontrol.

The Federal research role in this area has historically concentrated on unconventional sources of natural gas such as eastern shales, western tight sands, and coalbed methane. Industry efforts are now increasing in these areas, and the private sector has both the financial and technical resources to develop these new gas resources in response to market incentives. Consequently the unconventional gas recovery program has been scheduled for termination in FY 1983.

Unconventional Gas Recovery: (FY 1982 Appropriation: $8.712 million; FY 1983 Request: $ 0)

Industry has already begun to develop western tight blanket sands. As that technology evolves to cover the more difficult lenticular deposits, production from this resource should increase. And because there is a strong link between unconventional technology development and economic incentives, Federal activities in this area can begin to phase down. The resource evaluation for eastern Devonian shales is essentially complete and final verification of the results is expected to be done by industry. Thus, all geologic resource assessment activities will be phased down in FY 1982 and will no longer be supported by this program. Previous government-funded activities have demonstrated that methane can be extracted from coalbeds and used both with and without associated mining operations. The industry is better qualified to deal with barriers to commercial production and gas ownership; therefore, no funds are requested for this program in FY 1983.

Work in FY 1982 will be confined mainly to bringing the multiwell test in the western lenticular tight sands to a successful completion. To achieve a smooth shutdown of the Federal unconventional gas program, the Administration is proposing to cancel the third well of the multiwell project and eliminate all research dependent upon that well. Research at the site will be completed in FY 1982 with termination in FY 1983 or transfer of the project to industry. This action will permit $1 million to be deferred in FY 1982 for a subsequent reprogramming proposal.

PROGRAM DIRECTION

The FY 1983 request of $9.0 million for program direction ($8 million for the Coal program and $1 million for the Petroleum program) will provide funds for salaries, benefits and travel for Fossil Energy headquarters personnel during the fiscal year. The funding of these expenses for the Energy Technology Centers is provided in the program activities they support, not from the Program Direction line item.

CONCLUSION

In the past the Federal government has focused heavily on budgetary spending for fossil energy. In focusing on federal spending, the government in our view, failed to deal with the basic problems affecting energy in this country. For example, past policies artificially held the price of oil and natural gas below market levels. This discouraged the use of substitute fuels such as coal and also discouraged energy conservation and further discovery of oil and gas. The alternative approach, proposed by the President, involves a much broader strategy regarding energy and the overall economy. The funding proposed for the Fossil Energy programs should be judged in the context of this broader strategy involving less government spending, regulation, and taxation to achieve a simply energy policy objective -- the encouragement of efficient production and use of domestic energy resources.

The fossil energy budget we have proposed is part of an overall Federal energy budget that will save the American taxpayer nearly $10.5 billion by the end of FY 1983 compared to what the previous Administration intended during the same period. As President Reagan said in his State of the Union message, reducing Federal spending is one of four "commonsense fundamentals" of our Economic Recovery Program.

We ask this Committee to weigh our budget proposal in the same spirit and with the same contructive purpose as was evidenced last year. Through an open dialogue, we hope to show that this budget represents a realistic approach to building a sound knowledge base from which the fossil energy industry can select, further develop, and commercialize the technological options it deems most appropriate to meet our energy needs most efficiently.

Senator **Nickles** [presiding]. Thank you, Mr. Mares. We appreciate your input before this committee. I might ask a couple of questions. Am I correct that basically your proposal is that funding will be down to $107 million for fiscal year 1983?

Mr. **Mares**. That is correct.

ENERGY TECHNOLOGY CENTERS

Senator **Nickles**. Could you give us, rather quickly, on the five centers for last year, the research centers, could you give us their cost of what that was for last year, and then the two centers that will be maintained for 1983, what their cost would be?

Mr. **Mares**. We had a program last year wherein there was technology development work conducted at five energy technology centers at a cost of about $65–$70 million. The cost of maintaining the remaining centers would be around $43 million.

One of the most important aspects of the fossil energy program has always been that a substantial part of its work has been done in cooperation with industry as well as at universities, national labs, and energy technology centers. This is very important because the work that we fund will ultimately be transferred to industry; therefore, cooperative efforts with industry insure that we are focusing on work that is felt to be truly important, and allows us to fund work along with industry's funding which permits the Federal dollars to go further.

Thus, with a budget of $107 million, as well as reduced staffing from the current on board complement of about 1,100 to a total number of 511, it is inappropriate and managerially impossible to continue operations at all five technology centers in the same fashion as they have been in the past.

On reviewing that, I have made a tentative recommendation to the Secretary that we consider termination of three of those centers and continue activities at the other two centers, but at a reduced level.

So, of the five centers, the recommendation is that there be a reduction at two; and elimination of formal Federal activity at three sites.

In those three instances which involve the centers at Grand Forks, N.D.; Laramie, Wyo.; and Bartlesville, Okla., we have initiated conversations with other organizations, specifically the University of North Dakota at Grand Forks; the University of Wyoming in Laramie, and several both profit and not for profit institutes relative to Bartlesville with the hope and expectation that these entities would be prepared to undertake research activities at those sites. We would be prepared to transfer the facilities and employees to those new entities to conduct research at the funding level that we can afford in fiscal year 1983.

I would say that based on my conversations concerning these three centers, I am optimistic there will be the possibility of transferring the facilities to other institutions in a fashion that will enable the experience and capabilities of those centers to be continued, and that we would be able to continue to get productive research done for the Nation at those locations.

FUNDS AND PERSONNEL AT THE ETC'S

Senator **Nickles**. Out of those five centers for fiscal year 1982, I am familiar with the Bartlesville center. I think I was told that it basically had appropriations in the amounts of $20 million. Could you give me the breakdown on the other centers?

Mr. **Mares**. I don't have that in my head on each of the others, but you are correct. The total amount of funding that has been managed by Bartlesville is about $20 million; about half of that, about $9 million, was actually spent at the site.

[The information follows:]

FISCAL YEAR 1982 ENERGY TECHNOLOGY CENTER FUNDING SUMMARY

[In millions of dollars]

	Total managed	Managed in-house
Energy Technology Center at:		
Bartlesville	19.3	8.8
Grand Forks	5.9	3.9
Laramie	28.5	9.9
Morgantown	71.4	18.8
Pittsburgh	73.5	24.5
Total	198.6	65.9

Mr. **Mares**. We have what we call "lead missions" and in that capacity they are responsible for implementing the programs for which they are responsible, and that implementation means they do research at their own location, and they also contract with other entities such as universities, industry and national labs, to perform work at other locations.

Senator **Nickles**. I'm trying to get an idea, particularly on the West Virginia and Pittsburgh facility, how big in scope. How much are they spending this year?

Mr. **Mares**. Let me look up the exact amount for each center this year.

Senator **Nickles**. You probably also have the number of employees at each center.

Mr. **Mares**. I know that. The total number of Federal employees at Pittsburgh today is 359; and the total number of Federal employees at Morgantown is 205; the total number of Federal employees at Bartlesville is 150; at Laramie 157; and Grand Forks is 84.

In each case there are additional contract employees performing support services at those locations.

Senator **Nickles**. So, by employees, the Pittsburgh facility would be the largest. Last year we spent $417 million. The Bartlesville center spent $20 million, or this year, fiscal year 1982. If the others—if the total spending was about $20 million, you are talking about $100 million.

Mr. **Mares**. The total amount of 1982 funds that was managed at the centers was about $200 million, excluding proposed deferrals. But less than half of that was actually the cost of the research performed at the center.

There is a distinction between the research that we are buying and can be performed by the industrial firm.

Senator NICKLES. I understand what you are saying, but I would still kind of like to have an idea of about how much money is going through each particular center to get some type of scope. The Bartlesville center I believe is the oldest in the Nation. The total amount managed is about $20 million, so it had a very small percentage of the total amount of funds.

I'm trying to get—evidently Pittsburgh and Morgantown, W.Va., must be spending $100 million?

Mr. MARES. Both Pittsburgh and Morgantown are spending, by contract, substantially in excess of what they are spending at their own locations. I will get those numbers for you.

[The information follows:]

FISCAL YEAR 1982 FUNDING

[In millions of dollars]

	Total managed	Managed in-house
Morgantown Energy Technology Center	71.4	18.8
Pittsburgh Energy Technology Center	73.5	24.5
Total	144.9	43.3

Senator NICKLES. What prompted your recommendation—and I appreciate the fact you said it was your recommendation, that no final decision has been made as yet by the Secretary, but to keep two centers open—two centers that deal primarily with coal—in the eastern part, the Pittsburgh center and also the Morgantown center that are primarily involved in coal research, but not the ones that would deal with oil shale, which is probably a newer industry as such, and enhanced oil recovery which is important if we are going to try and maximize the amount of energy coming out of existing energy sources. What favored those two centers?

Mr. MARES. The factor that went into the decision was as follows. We have both a dollar limit and a staffing limit of personnel for fiscal 1983. I'm talking about fossil energy.

The staffing limit for fiscal year 1983 is a total of 511 full-time equivalent positions. In my judgment the appropriate balance between the field and the headquarters is 411 in the field and 100 at headquarters.

Today we have in the field—I didn't add up quickly those numbers, but I think it's around 850 full-time employees.

So there is no way that we can continue to operate each of the centers that we have today, the five centers in 1983 consistent with the way we are doing it today.

Furthermore, as a management principle, it seems to me that any center which we continue ought to be at a scale and size of effort to have a critical mass. It is more appropriate to terminate all Federal activity at a particular location and be sure that what we keep is large enough so that it is a viable entity than to try to weed out the same percent reduction in each location. I did not think that was a wise move.

That pushes me in the direction of concentrating my resources at various places. When I look at what we have in our program and the balance of our overall program it lacks a variety of technologies within the various resources. The substantial amount of our activity, about 85 percent of it, relates to coal. That work has been done at both Pittsburgh and Morgantown in the past.

Senator NICKLES. Eight-five percent of fossil fuels has been, in the past, in coal?

Mr. MARES. That's correct, and that's about the same percent currently in 1982. So, with a substantial percent of our activities being in coal, the two centers, the Pittsburgh and Morgantown being the two largest centers, and, with the desire to maintain a critical mass in place where we kept a federally staffed operation going, I made the recommendation that we move in the direction of termination.

Now, that was only part of the recommendation. It is also very important that there will be opportunities with other institutions at the three existing centers to develop a new relationship which could allow a continuation of research work at those sites. The office of fossil energy can fund some of that work. We can't fund everything that we would have been funding in the past, because our budget is much lower. However, I am optimistic that there will be a new organization, a new entity created, in North Dakota and Wyoming. I believe it can be done and that research can be performed at those sites using the existing facilities, probably employing a large number of the Federal employees that we currently have employed.

Throughout this transition there will be a continuation of the same type of work that has been done to date, and that will allow the Nation to get substantial value for its investment in the fossil energy program during this forthcoming year.

LARAMIE ENERGY TECHNOLOGY CENTER

Senator NICKLES. I am appreciative of the efforts you have taken to date as far as looking for a private source. As I have related to you privately, I have probably not that much objection, certainly as far as the total DOE budget as far as making some of the reductions that we are talking about making.

I would hope that the Department would maintain some flexibility to allow us to possibly be able to—I'm talking about total funding. I have no real objection even to the reduction in personnel, but give us some flexibility.

We are looking at DOE's total budget in anywhere from $15.5 to $17 billion. What is the facility in Laramie?

Mr. MARES. The lead mission of the facility in Laramie has been oil shale, underground coal gasification, and they've done work in tar sands as well.

Senator NICKLES. How much money are we talking about as far as Wyoming?

Mr. MARES. Their onsite operating expense has been approximately the same as Bartlesville, around $10 million. The programmatic dollars have been well over twice that.

Senator Nickles. The point—and I know I have made it to you before. I hope you would consider it—is some flexibility possible to move some of those dollars around? I personally have some reservations about maintaining the two larger centers, simply because they happen to be in coal. Also the Federal Government is involved through the synfuels project and so on, billions and billions of dollars in this type of research. I would hope we would maintain some flexibility as far as looking at the total amount of money that we are going to put in, as far as getting that money to do the most to help our country move toward increasing our energy output and so on.

My personal opinion is that we are going to get more oil or more energy per dollar probably through your oil shale research or through your enhanced oil recovery than you would just being in your coal. I would hope you would maintain some flexibility on that.

I guess I have some reservations about how you are allocating the $107 million, and our committee is willing to work with you. I certainly am. I visited that one facility. I plan on visiting some of the other facilities, possibly the coal and oil shale facility in the not too distant future. I think it's important. It is very important, so we will continue to work with you and work with you as far as the research, as far as finding outside institutes. It may be easier to do in Wyoming or North Dakota where they have the university that is particularly interested than it is in the Bartlesville situation.

I hope we can keep some flexibility. The Secretary has indicated to me that he would.

Mr. Mares. There has not been a final decision. I would say based on my conversations regarding each of the three locations, I am optimistic that we would be able to come up with a proposed solution which is responsive to the President's budget, and is responsive and acceptable to both the committee and the Congress.

Senator Nickles. I am appreciative of that, and will you continue to work with our office so we can keep you abreast of what we've found and vise versa?

Mr. Mares. I'd be happy to.

Senator Nickles. Thank you. I have some questions from Senator Wallop and Senator Simpson that I would like submitted for the record.

Senator Domenici [presiding]. They will be submitted.

Senator Ford—Oh, I have something to ask.

With reference to any of the three facilities that the Senator has been talking about that might be closed, and any other research facilities within your jurisdiction that might be the subject matter of closure, I understand you are making an effort to see that they are utilized in some way by institutions other than Federal Government.

Do you need any additional authority to maximize these opportunities? If you do, would you submit your request for that to the committee as soon as possible? Do you think you might?

Mr. Mares. In terms of an ultimate permanent transfer, I think authority would be required. My understanding is that there is authority in the DOE Act that will allow a facility to be leased for up to 5 years for energy purposes.

However, to the extent a permanent transfer was desired on the part of the lessee, and I believe that in each case that they are likely to want a permanent transfer, I believe that they would be desirous of legislation that would enable that to happen.

From my vantage point, we would be very supportive of that and plan to work with the Congress in order to accomplish that.

Senator DOMENICI. How does the Department, as far as you know, go about trying to find out whether there is a group institution, organization, or entity, that might be interested in using one of those facilities at a reasonable rate for research that is possible within the institution? How do you plan to go about it?

Mr. MARES. Well, we have visited with the congressional delegations in each of the States in which we were going to recommend this type of transfer, and asked those delegations what their suggestions were as to institutions that we might talk to and how we should proceed. We have followed that.

We have talked to the University of North Dakota at the suggestion of the delegation from North Dakota. Similarly we have talked to the University of Wyoming at the suggestion of that State's delegation.

To refresh the recollection of the committee, the two energy technology centers in Grand Forks and in Laramie are physically contiguous with the respective universities.

With respect to Bartlesville, we reviewed the situation with the congressional delegation and then had a meeting with members of the community and the chamber of commerce, to receive names of institutions that would be interested in taking over the center. There has been significant publicity concerning this option and several profitmaking firms as well as not for profit institutes have contacted us. We have filled in the congressional delegation on the outcome of these discussions and have suggested that they expand the horizons of that laboratory to perform work not simply for the Office of Fossil Energy, but to perform work for potentially other Government agencies or State or non-Government activities.

PILOT PLANTS

Senator DOMENICI. I understand that there are some pilot facilities in addition to the three labs you were speaking of, and there may be some significant equipment around.

If the present budget, in precise detail, is adopted as an appropriate guide, is it correct to state that some of those would no longer be needed either.

Mr. MARES. That's correct.

Senator DOMENICI. Do you approach their possible utility in the same way?

Mr. MARES. No. We are approaching those pilot plants in a quite different way. In most cases there is a contract that provides for the ultimate termination of the relationship. In some cases we have already initiated discussions with the operator, builder or owner of the pilot plant, in regard to termination of that relationship. That's being looked upon quite differently than is the case with the three centers.

Senator DOMENICI. Mr. Secretary, I have no quible with what you've done at this point, but it does appear to me there has been historically for a substantial number of years an under investment in research facilities. Not necessarily these, but nationally.

I would hope if these are going to be closed as far as the Federal Government, that we miss no opportunity to give groups of universities and groups of business people the maximum opportunity to attempt to project their utility for research.

I know this committee would stand willing to assist by way of any kind of legislation you might need to assist you.

It does appear to me that you are moving in the right direction. I hope that at the university level that the fact that they are approximate to some university does not preclude either that university or you seeking other universities who use it also; thus making it more feasible.

A number of excellent facilities that the Federal Government runs are run on the basis of outsiders using them. A very large array are in Mexico that are a fantastic resource. They submit proposals from all over the world to use it, and then peers look at it and say you are next and they have 16 or 18 months. People come in and they only pay the overhead and use it. I don't know that any of these are that exotic, but I think you've got to go as far as you can. I think mothballing is really the last resort.

Mr. MARES. I agree with you wholeheartedly. If we can come up with a way for the country to get the value above and beyond what fossil energy will seek from these facilities, then I am optimistic.

Based on the conversations I've had with both universities as well as some of the people that have expressed an interest in Bartlesville, they look upon this as an opportunity to expand on horizons of those facilities and not to narrow them.

Senator DOMENICI. Thank you very much.

Senator FORD. I agree with the chairman's concern as it relates to the transfer of property. I remember, what is it, the Carnegie Mellan—the swap of land—and we had quite a period of time there before we could accommodate to that.

I don't think it's going to be very easy, even under the DOE Act, just to transfer an entity to somebody. I'm always concerned when I talk to a chemical engineer with a legal background. If he can't get me one way, he can get me another. I want to be very careful.

Have you, to any of these institutions that you've discussed it with, offered them any research money or have they asked for any research money if they take the institutions?

Mr. MARES. What we are going to——

Senator FORD. I'm going to try to ask you questions where you can give me a yes or no answer.

Mr. MARES. Yes, we have.

Senator FORD. You are going to create the incentive financially to that institution for them to take it off the Government's hands, and it might be just as well. We'd have other research that you are interested in that could be put in there and we could do it and keep the installation and go ahead and proceed under the present operation without giving an institution funds to take over something by deed from the Federal Government.

Mr. MARES. May I respond?

Senator FORD. How about building one down in Kentucky? We will find somebody that will take it.

Mr. MARES. I think the issue, Senator, is not only a matter of money. It is a matter of the number of people to perform the work.

The recommendation that I came up with is that we would be unable to continue as a Federal operation, continue with five laboratories.

Senator FORD. What you are saying is you are not going to have enough money under the present proposed budget. It's obvious you are going to give those three away, or you intend to give them away, because there is nothing in the budget for maintenance and repair and upkeep and that sort of thing. They are going to deteriorate if something doesn't happen, if we don't move very quickly.

I see the Government and the taxpayers being had here in this if we don't go ahead and move quickly to dispense with them to see that another entity takes them over and they function, or we keep them in some sort of maintenance and we then shift gears into tar sands or oil shales, or whatever it might be that others are interested in.

I would be very hopeful that we wouldn't let it linger until it is in mothballs, for all practical purposes, without any maintenance.

Mr. MARES. I agree with that.

Senator FORD. By the way, we spent about $66 million in Kentucky doing research in coal, so we are not asking the Federal Government to do it all. We have, I think, a pretty decent laboratory that the Federal Government didn't participate in one dime to build, so there are others out there trying to do something in research and development.

Let me ask you, Mr. Secretary, the proposed budget, in your opinion, is it adequate to do all the required research on fossil energy?

Mr. MARES. Yes, sir.

Senator FORD. You think it's adequate, the $107 million?

Mr. MARES. Yes, sir.

Senator FORD. I mean the $106 million is adequate?

Mr. MARES. Yes, sir.

Senator FORD. Why did you argue for $389,276,000 then?

Mr. MARES. In the course of preparing the budget several different decisions were made.

Senator FORD. By whom? OMB? You said this is it. This is all you're going to get?

Mr. MARES. The administration reviewed several proposals before coming up with a final judgment as to what is the appropriate amount of money to meet the needs of fossil energy. In our judgment it's $107 million.

Senator FORD. You asked for $389 million and the agency suggested that $305 million, and you finally got $106 million. Even your request was reduced. You say that is adequate?

Mr. MARES. Yes, sir.

Senator FORD. Boy, you had a change of heart there all of a sudden.

If the Congress were to give you additional funds, can you use them productively?

Mr. MARES. I don't think we need additional funds.

Senator FORD. What if you get it anyhow? What are you going to do with it?

Mr. MARES. I would hope that Congress wouldn't give us additional funds.

Senator FORD. With that kind of attitude, I'm not sure we ought to give it. Maybe we can find some university out there that you are getting ready to give one of these operations to. Maybe they can do a better job than the Federal Government in the first place.

Would you object if we found some ability to do that and let us do the funding rather than go through DOE? You are going to dismantle it anyhow.

Mr. MARES. We are going to transfer our office to the Department of Commerce.

Senator FORD. But your Secretary testified you wouldn't save any money by doing that and it would probably cost you some. You've already made savings and, therefore, there is no more savings left.

Mr. MARES. I think the Office of Fossil Energy will do very well in Energy Research and Technology Administration.

Senator FORD. Well, it's going to be a little interesting debate as relates to what happens.

Did you make any kind of a fight for the money that you originally requested in the Internal Committee before it went to OMB? You had to have some reason for asking for $389 million plus.

Mr. MARES. I think in the course of reviewing any matter I have presented points of view and ideas to my management, and they were considered in the decisions, yes, sir.

Senator FORD. OK, so they won't disagree with what happened; even though now you are saying it's adequate.

Would you give the committee a ranking order after the priority of the funding that was eliminated from the Department's submission to OMB so that Congress might give consideration to that ranking of those projects that will now be eliminated under the present budget? Could you give me a ranking of one, two, three, four?

Mr. MARES. Senator, I have not asked myself or made any analyses of what might happen if Congress decided to add additional money, so I do not have such a list for you.

Senator FORD. Apparently you had some preferences in your first request to the Internal Committee. Those requests amounted to $389 million plus, and then it came down to $305. Apparently there was some kind of ranking and some money allocated under a line item for various portions of research and development in fossil fuel.

Mr. MARES. Yes, sir.

Senator FORD. Can I have the list of those that will not now be funded under the proposed budget?

Mr. MARES. I believe if it has not already been made available, I believe it can be made available.

Senator FORD. Would you make that available to me.

Senator DOMENICI. So you don't think he is planning to give you something he is not agreeing to, that is not priority.

Senator FORD. No. He doesn't have a priority list, but there will be a group that is not funded and I would like to have that group that will not be funded between $389 and $106, and I will make my judgment.

Mr. **Mares**. I think the $305 is a number that I could provide for you. I don't believe I've got the $389 mix that you are describing.

Senator **Ford**. Somebody has it. I don't know whether you have it or not, but your Department asked for that much originally in the internal request. I have the printout.

Mr. **Mares**. The issue is the detail on the various line items. I am in my own mind uncertain as to the detail with the respect to the $389.

Senator **Ford**. You have the detail of the $305?

Mr. **Mares**. I know what the detail is on the $305 request.

Senator **Ford**. Then we will have no problems getting that. I'm not expecting to go back and pick up every little piece of paper. Sometimes I make notes on matchbooks and backs of envelops, but I hope you can find that. That would give us some idea what the DOE really said to OMB that they thought was the proper amount to be funded.

Mr. **Mares**. The Department request was $305, and I can provide that information.

[The information follows:]

R&KHOLFD

13:31 2/11/82

DEPARTMENT OF ENERGY
FY 1983 O M B BUDGET REQUEST
(DOLLARS IN THOUSANDS)

BY APPROPRIATION

A/S CODE	ACCOUNT TITLE	FY 1982 B/A ENACTED	FY 1983 B/A A/S REQ.	FY 1983 B/A OMB REQ.	FY 1983 B/A CONG. REQ.
992500	FOSSIL ENERGY				
50005	COAL				
50009	MINING R&D				
50010	OP. EXP. & CAP. EQUIP............................	10,992	14,145	7,000	1,000
50011	CONSTRUCTION....................................	-----	-----	-----	-----
50012	TOTAL, MINING R&D................................	10,992	14,145	7,000	1,000
50014	COAL LIQUEFACTION				
50015	OP. EXP. & CAP. EQUIP............................	98,784	54,850	51,600	26,200
50016	CONSTRUCTION....................................	129,600	-----	-----	-----
50017	TOTAL, COAL LIQUEFACTION.........................	228,384	54,850	51,600	26,200
50019	SURFACE COAL GASIFICATION				
50020	OP. EXP. & CAP. EQUIP............................	53,088	46,070	40,761	10,500
50021	CONSTRUCTION....................................	-----	-----	-----	-----
50022	TOTAL, SURFACE COAL GASIFICATION..................	53,088	46,070	40,761	10,500
50024	UNDERGROUND COAL GASIFICATION				
50025	OP. EXP. & CAP. EQUIP............................	8,256	12,800	700	700
50026	CONSTRUCTION....................................	-----	-----	-----	-----
50027	TOTAL, UNDERGROUND COAL GASIFICATION..............	8,256	12,800	700	700
50029	ADV. RESEARCH & TECHNOLOGY DEV				
50030	OP. EXP. & CAP. EQUIP............................	52,416	65,405	51,657	17,000
50031	CONSTRUCTION....................................	3,840	-----	6,350	2,800
50032	TOTAL, ADV. RESEARCH & TECHNOLOGY DEV.............	56,256	65,405	58,007	19,800
50069	CONTROL TECHNOLOGY & COAL PREPARATION				
50070	OP. EXP. & CAP. EQUIP............................	25,152	27,585	29,000	8,600
50071	CONSTRUCTION....................................	-----	-----	-----	-----
50072	TOTAL, CONTROL TECHNOLOGY & COAL PREPARATION.......	25,152	27,585	29,000	8,600

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A/S CODE	ACCOUNT TITLE	FY 1982 B/A ENACTED	FY 1983 B/A A/S REQ.	FY 1983 B/A OMB REQ.	FY 1983 B/A CONG. REQ.
50074	HEAT ENGINES AND HEAT RECOVERY				
50075	OP. EXP. & CAP. EQUIP............................	15,408	17,000	6,350	-----
50076	CONSTRUCTION....................................	-----	-----	-----	-----
50077	TOTAL, HEAT ENGINES AND HEAT RECOVERY.............	15,408	17,000	6,350	-----
50084	COMBUSTION SYSTEMS				
50085	OP. EXP. & CAP. EQUIP............................	41,044	46,990	23,895	6,500
50086	CONSTRUCTION....................................	-----	-----	-----	-----
50087	TOTAL, COMBUSTION SYSTEMS.........................	41,044	46,990	23,895	6,500
50094	FUEL CELLS				
50095	OP. EXP. & CAP. EQUIP............................	34,464	29,545	22,500	9,500
50096	CONSTRUCTION....................................	-----	-----	-----	-----
50097	TOTAL, FUEL CELLS.................................	34,464	29,545	22,500	9,500
50109	MAGNETOHYDRODYNAMICS				
50110	OP. EXP. & CAP. EQUIP............................	27,840	-----	-----	-----
50111	CONSTRUCTION....................................	-----	-----	-----	-----
50112	TOTAL, MAGNETOHYDRODYNAMICS.......................	27,840	-----	-----	-----
50120	PROGRAM DIRECTION - COAL..........................	12,019	12,520	12,350	8,000
50125	CAPITAL EQUIPMENT - COAL..........................	-----	-----	-----	-----
50130	SUBTOTAL, COAL....................................	512,903	326,910	252,163	90,800

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A/S CODE	ACCOUNT TITLE	FY 1982 B/A ENACTED	FY 1983 B/A A/S REQ.	FY 1983 B/A OMB REQ.	FY 1983 B/A CONG. REQ.
50135	PETROLEUM R&D				
50149	ENHANCED OIL RECOVERY				
50150	OP. EXP. & CAP. EQUIP..............................	15,456	21,700	18,700	5,800
50151	CONSTRUCTION.......................................	-----	-----	-----	-----
50152	TOTAL, ENHANCED OIL RECOVERY.......................	15,456	21,700	18,700	5,800
50154	OIL SHALE				
50155	OP. EXP. & CAP. EQUIP..............................	18,192	19,730	16,757	6,300
50156	CONSTRUCTION.......................................	-----	-----	-----	-----
50157	TOTAL, OIL SHALE...................................	18,192	19,730	16,757	6,300
50144	DRILLING AND OFFSHORE TECHNOLOGY				
50145	OP. EXP. & CAP. EQUIP..............................	-----	-----	-----	-----
50146	CONSTRUCTION.......................................	-----	-----	-----	-----
50147	TOTAL, DRILLING AND OFFSHORE TECHNOLOGY............	-----	-----	-----	-----
50139	ADVANCED PROCESS TECHNOLOGY				
50140	OP. EXP. & CAP. EQUIP..............................	3,552	4,756	4,500	3,000
50141	CONSTRUCTION.......................................	-----	-----	-----	-----
50142	TOTAL, ADVANCED PROCESS TECHNOLOGY.................	3,552	4,756	4,500	3,000
50160	PROGRAM DIRECTION - PETROLEUM......................	1,555	1,620	1,600	1,000
50165	CAPITAL EQUIPMENT - PETROLEUM......................	2,160	-----	-----	-----
50170	SUBTOTAL PETROLEUM.................................	40,915	47,806	41,557	16,100

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A/S CODE	ACCOUNT TITLE	FY 1982 B/A ENACTED	FY 1983 B/A A/S REQ.	FY 1983 B/A OMB REQ.	FY 1983 B/A CONG. REQ.
50175	GAS				
50179	UNCONVENTIONAL GAS RECOVERY				
50180	OP. EXP. & CAP. EQUIP.	11,520	14,100	11,000	-----
50181	CONSTRUCTION	-----	-----	-----	-----
50182	TOTAL, UNCONVENTIONAL GAS RECOVERY	11,520	14,100	11,000	-----
50185	PROGRAM DIRECTION - GAS	442	460	450	-----
50190	CAPITAL EQUIPMENT - GAS	192	-----	-----	-----
50200	SUBTOTAL - GAS	12,154	14,560	11,450	-----
50205	PROGRAM DIRECTION	-----	-----	-----	-----
50209	FEASIBILITY STUDIES				
50210	OPERATING EXPENSES	-----	-----	-----	-----
50211	PLANT AND CAPITAL EQUIPMENT	-----	-----	-----	-----
50212	TOTAL, FEASIBILITY STUDIES	-----	-----	-----	-----
50219	LEASING PROGRAM				
50220	OP. EXP. & CAP. EQUIP.	-----	-----	-----	-----
50265	TOTAL, FOSSIL ENERGY	565,972	389,276	305,170	106,900
50255	RESCISSION - FE (FE)	-----	-----	-----	-----
50260	COST OUTLAY ADJUSTMENT - FE (FE)	-----	-----	-----	-----
50261	FY1981 DEFERRAL - FE (FE)	-19,500	-----	-----	-----
50262	FY1981 DEFERRAL - (FE) FE (CONST)	-129,600	-----	-----	-----
992590	TOTAL, FOSSIL ENERGY	416,872	389,276	305,170	106,900
992591	(OP. EXP. & CAP. EQUIP.)	413,032	389,276	298,820	104,100
992592	(CONSTRUCTION)	3,840	-----	6,350	2,800

Senator **Ford**. That's what they thought they should have to fund this particular area?

Mr. **Mares**. Yes, sir.

Senator **Ford**. On page 1 of your testimony you show projections of energy supplied in the year 2020, with fossil energy dropping from 90 percent to 70 percent of the supply, and with hydro and new sources; I presume are largely renewable sources providing approximately 16 percent.

I suspect the decline in the fossil energy contribution as a result of Government policies is discouraging the growth and use of coal.

What are the elements of Government policy necessary to achieve an increase in utilization of coal?

Mr. **Mares**. I know of no basis for your conclusion that the reason it's only 70 percent is due to a Government policy to discourage the utilization of coal. I believe that there are in place several policies to encourage the utilization of coal, and one is the movement toward deregulated energy sources in this country. Another is the regulatory reform package and the approach that the administration is supporting.

I think the technology base that we have within fossil energy is directly in support of coal utilization. It is one of the priorities that we have in our program to provide the technology base from which industry can develop the technical concepts and take them to commercialization. I think there have been significant numbers of successes in that regard which are already showing increased, or helping to increase, utilization of coal.

Senator **Ford**. You make the statement on page 1 because of economic incentives the sector is well positioned to commercialize new technologies with minimum Government help. What are the economic incentives that you are citing?

Mr. **Mares**. I think the fossil energy industry is one of the most vital industries in this country, and it is, like other industries, taking new technologies and utilizing them in response to the demands of the marketplace as those demands have developed. I think that the marketplace is one of the things that will provide the greatest incentive to the fossil energy industry as it develops and shows an increased utilization in coal.

Senator **Ford**. Can you give us an example of technology in process development unit stage which might be deserving of cost-sharing basis of Government industry?

Mr. **Mares**. We have several technologies that are in the bench scale, some in proof of concept. There is cofunding within fuel cells. We have some cofunding in the coal liquefaction area at Wilsonville process development unit.

We have been cofunding in the heat engines area and that is now coming to fruition in the sense of where our role will be completed.

Senator **Ford**. You talk about Wilsonville. Since you've been to Wilsonville and you refer to that, how is the pilot plant doing at Wilsonville? I'm talking about the SRC-1?

Mr. **Mares**. SRC-1 has used Wilsonville as a facility to test concepts on which the design for SRC-1 will be based, and that work has been going along for several years.

The work that is required to do the base line estimate has been completed. At this moment, it is not certain how much more work will be required by SRC-1.

Senator FORD. Is it showing some market results? Do you have any judgment on that?

Mr. MARES. On SRC-1? The base line estimate for that is due to be submitted to Congress on the first of June. We originally had planned to have it for you by the first of May, but we will not be able to meet the first of May deadline. When we receive the base line data, we will review it and make a recommendation regarding what our view is about any future activity.

Senator FORD. Do you have any preconceived notions about it?

Mr. MARES. I think it has gone very far in the commercialization direction, and that's a level of activity which the administration does not believe is appropriate for Government funding.

I would expect when the project, the base line estimate, is completed that we would analyze it, present it to Congress and then make a judgment as to what we would recommend for using the remaining funding.

Senator FORD. Would you say it's in the category of the synfuels corporation request?

Mr. MARES. I do not know if they have already submitted an application.

Senator FORD. I don't think they have, but would you say it would be in the category of the synfuel corporation?

Mr. MARES. I think it is at a stage where if they chose to apply, the Synthetic Fuels Corp. is the organization within the Government that is able and should consider the SRC-1 technology development.

Senator FORD. Let me ask you this. As I understand it there is a prohibition basically on demonstration as it relates to funding of that from the synfuels corporation.

Many of those who I think are eligible in synfuels corporation might want to fund themselves, even though the biggest of big of industries in this country find it very difficult under the restraints that we applied several years ago to come up with the funds that are required of private industry.

Would you or would you not be willing to entertain a position of increasing that relative percentage, based on inflation and other factors, to increase the $3 billion limit to which you would be in the real dollars of the time we passed the legislation? I'm talking about the 10-percent inflation, or whatever factor. You would be able to increase that twice on the increased cost of that facility at the time providing the funds are there and everything else is equal.

Mr. MARES. Sir, I'm sorry. I just didn't follow the question.

Senator FORD. We have $3 billion cap. And we say at the time we put the $3 billion cap on it that would probably accommodate at a 60/40 split, and the 40 split gets beyond the ability of the company that's on the verge of making it work. With a little additional help from the Federal Government, based on inflation and other cost factors, it increased the cost of those plants, would you be willing to entertain a triggering mechanism that would allow them to go beyond the $3 billion which is the loan guarantee basis?

Mr. **Mares**. Senator, I have not participated in reviews or consideration of the issues evolving around the cap and the particulars of selecting individual projects.

Senator **Ford**. I'm not talking about individual projects. I'm just talking about the cost factor without anything else, everything else being the same, but we are getting into the cost factor of private enterprise. There is a good many dollars over there. I don't know whether we keep them going over there or not under the present circumstances, but there are a good many dollars there that could be used at least for a limited number of approvals.

I think you are going to find a smaller unit, under the circumstances, being approved that come under the cap; where you would want maybe to go to a larger unit that might now go over the cap and prevent the private sector from participating.

Mr. **Mares**. I think the people that are most qualified to respond to that are at the SFC and not myself.

Senator **Ford**. I'm talking about the technology we want to follow.

Mr. **Mares**. I understand that, but I guess I hesitate to agree automatically to change a cap limit without considering what are the implications of doing so.

Senator **Ford**. The implication is it costs a little more money from the Federal Government to give private enterprise an opportunity to make it work. That's simple.

Senator **Domenici**. Are you referring to a Synthetic Fuel Corporation cap? He doesn't have anything to do with that, does he?

Senator **Ford**. He is in the research and he is going to be developing new projects. If they are going to the Synthetic Fuels Corporation for funding of the commercial operation, he is saying now that most of these items that are being cut from the budget are basically ready to go to commercial. The only place they can go for the funding will be to the Synfuels Corporation.

If those projects are now being hampered because of the accelerated cost and because we have delayed the funding—like the tar sands project in Canada was $2 billion when it was built, and now it's $10 billion to build an identical plant like that.

All I'm saying is you are doing the research, and if you wanted to get it out on the board, I wonder if you would be willing to entertain that kind of operation.

I may not be making myself clear, but I'm trying to get these commercial projects on board and try them.

Mr. **Mares**. I think that is clearly the intent of the SFC, to select projects and get them up and running. I think it's clear they look upon this as their mission and would expect to be selecting from their first 11—I call them summer finalists—here at the end of this month.

Senator **Ford**. What I am afraid of is some of the summer finalists, or the finalists that are selected, you are going to find some of the smaller entities that will not make any impression on the economy, or will not be funded even though the Corporation would like to do it.

They are strong and they're big and you are talking about billion dollar corporations, but they are still not individually large enough to carry that load without having the scale up where the Federal Government would give them a larger loan guarantee.

I want some kind of attitude on that, because I think we are going to have to have one, or we are not going to see as many of the various kinds of synthetic fuels operations.

Mr. MARES. I think we, the Nation, will have a much better view in a month or so when the selection process at SFC proceeds.

Senator FORD. Let me make a prediction to you. You will find the small entities that are approved will go forward. The larger ones will not be able to that are approved. That will be my judgment.

I think we've got ourselves in a catch-22 position and can't get out of it.

Senator DOMENICI. I don't know that this particular witness could answer that. Mr. Secretary, do you familiarize yourself in your capacity within the Department with the kinds of technologies on the product that the Synthetic Fuel Board is considering funding?

Mr. MARES. Yes, in a generic sense. We are not participating in the selection process, but we do work closely with the Synthetic Fuels Corporation and have a memdorandum of understanding regarding our relationship to be able to provide them technological information; and I would certainly pass on to them, in the course of my conversations, the point that——

Senator FORD. Your final product and which you've approved in the new energy resources that you are trying to get into and making judgments on will never come to fruition unless there is some flexibility in the cap.

We are getting to that part. I just want a philosophy or—I don't want your endorsement.

Mr. MARES. I'm not sure I agree with you that they will never come to fruition.

Senator FORD. Not on short term anyway, with the interest rates, the attitude that we have now. We are just going to sit here and look at them.

Mr. MARES. We are continuing to fund work in fossil energy R&D. We're not just sitting back.

Senator DOMENICI. Senator Ford, could we move on to Senator Melcher? We have to have the next group of witnesses also.

Senator FORD. I wanted to tell Senator Nickles—I see he's gone—but you've increased the research and development in the petroleum field considerably. You've increased it to 16 percent over 10 percent. The budget cut was up by a factor of 4, and as I see it the percentage of your budget increases to 16 percent.

Mr. Chairman, I apologize for taking so long. I have an intense interest in this and I get carried away. I apologize for that. I have additional questions that I would like to submit for the record.

Senator DOMENICI. We will submit some questions tomorrow and you can answer them as soon as possible.

With reference to Synthetic Fuel Board activity and the caps that are the result of the way that pot is going to be split up, I think the Senator is asking if you will review those at the appropriate time, looking at them from the standpoint of whether there were projects that will not be able to proceed within the caps that the Department of Energy has a genuine interest in, in terms of the technology mix that you have been promoting.

In the event that you find that the cap has been an inhibitor, would the Department, through your Secretary, submit such an indication to the committee?

Mr. MARES. I would be pleased to do so.

Senator FORD. I just want a philosophy. I don't want a flat out endorsement if that cap is inhibiting the research.

Mr. MARES. As you know, they have set out standards to basically encourage a rather wide range of technologies to be considered, and we are very supportive of that concept.

Senator FORD. You take the coal, oil, water operations, that is one of those in the final consideration. There are already those that are funded and on line producing about 6,000 barrels of oil per day. So that's already out there and going.

Mr. MARES. They have come a long way in their approach to development.

Senator FORD. I would hate to see that—and I'm not sure that I will—but I'm trying to hedge my bet if I can to see that we don't lose in this SRC run that jump from the pilot stage to going to the board as a commercial operation.

The demonstration project is a pretty involved and costly operation. I'm not sure that they can make the jump from pilot to commercial, but I think we ought to try and encourage them as much as we can. If they can go as a demonstration or shift from pilot directly to commercial as each will do——

Mr. MARES. I think that was the design plan when it was charging at 6,000 tons a day. That is the scale from which you could make a professional judgment to go toward a commercial scale plan.

Senator FORD. It's 600, isn't it?

Mr. MARES. I beg your pardon.

Senator DOMENICI. Senator Melcher, could I ask a couple of questions?

The Great Plains project has not been transferred to the Synthetic Fuels Corporation.

Mr. MARES. No, sir.

Senator DOMENICI. Briefly, how is it going?

Mr. MARES. I'd say it's going very well. The working relationship within the Department, we have developed the monitoring program within our Department that involves my office, and the operation offices. We've had meetings with the management group of Great Plains. I think they are responsibly and responsively at work to make sure that that project comes along.

Senator DOMENICI. How is the cost coming? Is it overruns or coming within estimates?

Mr. MARES. You will never know until the final dollars are spent, but in the review that I attended in January the estimates of the project were that it would be within the budget that was forecast.

Some lines were more expensive and some were less, which is what you would expect as the project proceeds forward in development.

ENHANCED OIL RECOVERY AND ENHANCED GAS RECOVERY

Senator DOMENICI. Enhanced oil recovery received funding. I have no objection to that. I think it's appropriate, but I note enhanced gas recovery is cut. I don't understand the rationale.

Mr. MARES. In enhanced gas recovery, there have been three programs that we are wrapping up this year that we think have been very successful. These programs involve methane coalbeds, eastern gas shales where we have provided data to the industry and a multiwell experiment in the tight lenticular sands in the West where there are substantial reserves.

The incentives that are available today because of the increasing price of natural gas, and the experience of industry in developing fracturing techniques in the tight blanket sands in the West, lead us to conclude that they will move in an evolutionary way to develop the tight lenticular sands in the West.

We have, as I mentioned, an experiment that is underway there. We have completed two wells much closer together than normal that we have highly instrumented in which we are going to perform tests. Our plan and expectation is that we would try to develop an industry group to take those two wells and tests and build upon it either with two wells, or by adding a third well which was the original plan when we conceived the experiment.

The judgment is that there is substantial incentive for the private industry to develop technologies for moving in this direction.

With respect to the enhanced oil recovery, a significant part of that work revolves around collecting data and analyzing it as a result of the Economic Regulatory Administration incentives program that was started several years ago in various enhanced oil recovery projects. Data from various projects comes into the Department, and we are putting together a data base and developing models which can be used to project the various types of enhanced oil recovery activities that would be potentially best for the particular technology.

We are also doing work in heavy oil involving thermal stimulation. Heavy oil represents an enormous reservoir of oil for this country and for the world. We are completing in 1982 the down hole steam generator which was developed both by our offices and private sector firms. There will be a final test of this device in a joint international program involving Canada toward the end of this fiscal year.

Our judgment was that we could, in fact, withdraw from the Federal funding in research for unconventional gas, because industry is moving in that direction; and there are still things that are appropriate and important for us to continue to do in enhanced oil recovery.

Senator DOMENICI. As I said, I am very encouraged that you stayed on enhanced oil. I think it has enormous potential. Venezuela apparently would be extremely interested, and California seems to be.

I have one last question. How does your synthetic fuel component in years 2010 and 2020 compare with other major predictors of the mix, of the energy mix? Do you look at any major oil companies, what they say the mix will be at the turn and at 2010 and 2020?

Mr. MARES. Yes, I have looked at those.

Senator DOMENICI. How does the synthetic fuel part compare with other predictions of the mix? Do you remember?

Mr. MARES. This is from the Department of Energy's energy policy plan that was presented to Congress last summer. My recollection from looking at other forecasts was that this is in the ball park of the other forecasts. This is our best guess from the various people that are forecasting these things.

Senator DOMENICI. I think it is slightly higher than, but in the ball park.

Mr. MARES. I think that's probably right.

Senator MELCHER. Secretary Mares, the people in this country have a hard time understanding the credibility of some things. Most of them have nothing to do with your job.

In order to save some money in this budget so we can send $100 million to El Salvador, that's a little bit hard to understand; that $250 billion plus for defense, that's a little hard to understand for most people. To cut back on some energy things won't mean much to people that are facing our every day bills, today, this year or next year. Not many can look at what you're doing in R&D and say well, that will help us next year or the year after.

Those of us that sit here in Congress year after year will understand what happens when you shift these priorities. Let me just start out on one where you do have something to say about, or the Department has something to say about. Let's talk about cleaning up the steam to get down into the oil and be able to bring it out more efficiently. I just spent a good deal of Sunday in the oil fields near Bakersfield where they do steam inject those wells. Last year you spent about $7 million on that R&D to get a better system, and you are going to spend another $2 million this year. That comes to about $9 million for the last couple of years. And I suspect the year before that there might have been some money in there too.

That's the type of money that these oil companies can swallow without their Adam's apple even bobbing. That type of money for R&D is something that the private sector can, will, and does absorb.

They are getting the oil out where the wells sit there in that particular field about 40 feet apart. They are getting that oil out and they will continue to get it out, regardless of whether this R&D does or does not go forward.

We have consumers in my State, not hit as hard as those in the State of Washington, and those particular customers are going to have their rates doubled this year, and maybe double again after that the following year. That includes not just farmers and ranchers, it includes those small business people.

So, we are really looking at the inflationary pressures. The people of this Nation like to see, I think, something down the road that says they make a little better deal out of their electric bill and see it level off at some point.

Now, in this budget, the part that you don't have anything to do with—the nuclear; we are going to hear from them in a minute. For R&D for coal there is a total of $90 million. Now, that's about a ratio of 12 to 1. The coal that we've got in this country, as you point out in your testimony, is probably—well, as I understand, the Department of Energy in the MHD work, they clearly outlined during the past several years that the MHD would improve the efficiency of coal from about 34 percent efficiency to something over 50 percent. The Department believes that the MHD technology would improve the problem with air quality bringing about the burning of coal without any sulfur dioxide problems and, further, that water requirements would be much lower than the conventional steam generation.

Now, that's the Department's thinking over the past several years, and it's born out by MHD projects that are going on in other countries as well as the private interests here in the United States who have been involved in the MHD research for the past 20 years.

Now, our State happens to have a lot of coal in the Powder River Basin of Montana and Wyoming. Most of the coal is shipped out and going as far as the Great Lakes, or as far as Houston. The transportation charges run up to as high as $25 per ton, which is now more than twice the cost of coal.

I want to point out that that's an inflationary factor that is not under control at all, the escalation of transportation costs per coal.

Returning to the point of efficiency, if the efficiency is projected by the Department of Energy in MHD projects and accepted by both private sources here in this country and foreign sources increased from about 34 percent to something over in the range of 50 percent, then you get the same number of kilowatts generated from fewer tons of coal. When you get the 40 and 50 percent more kilowatts generated per ton of coal, the transportation bill would be leveled off because you transport less coal. It is an inflationary factor that hasn't been brought into the Department's reconing on the value of the MHD program? I don't know why that hasn't been brought in. Has it been?

Mr. MARES. Implicitly, yes, sir.

Senator MELCHER. What do you mean by that?

Mr. MARES. We are working on several different technologies that promise higher efficiency utilization of coal at the use point. Those technologies include pressurized fluidized bed. There is a commercial demonstration of integrated gasification combined cycle with the cool water project in southern California.

Senator MELCHER. Why would you generate electricity using that?

Mr. MARES. You could generate electricity any place.

Senator MELCHER. At what cost is it projected?

Mr. MARES. The efficiency on that is not as high as is claimed for the MHD. As that evolves it will not be expected to be as high as MHD, but that's only one of several that we are working on. Fuel cells have potential efficiencies that are above 50 percent, so MHD is not the only technology that is available to get higher than 50 percent.

Furthermore, we are working on several options for the country to generate electricity on a highly efficient, environmentally acceptable basis.

Senator MELCHER. Which of those are central-based generation?

Mr. MARES. Fuel cells, PFB and integrated combined cycle.

Senator MELCHER. Then why don't we talk about a 4.5 megawatt for fuel cell? Is that the central base generation?

Mr. MARES. When it is ultimately expanded. The beauty of the fuel cell technology is that it's modular in capability and can be put on in very small step functions.

The difficulty with MHD is you have to build an enormous plant to have it be economically effective. Fuel cells don't have that hindrance.

Senator MELCHER. What do you mean by enormous?

Mr. MARES. The perfect project for this concept is going to cost around $500 million.

Senator MELCHER. What size plant are you talking about?

Mr. MARES. For proof of concept? Two hundred megawatts.

Senator MELCHER. 250 thermal? Or is that 250 actual?

Mr. MARES. 250 actual electrical output from the combined cycle MHD system.

Senator MELCHER. About a half billion dollars?

Mr. MARES. Including the technology and development that has to go along with the hardware.

Senator MELCHER. It's going to be over a billion dollars before it's done.

Mr. MARES. But there is no certainty that even for——

Senator MELCHER. This is for each, not for one, and for about 1,000 megawatts. So you are saying that for about a half billion you could build a 250 megawatt MHD plant?

Mr. MARES. What I am saying is for that amount of money there are other technologies that we are working on wherein I think the country will get more value.

Senator MELCHER. If you look back, Mr. Secretary, I think that would figure out to about $2,000 per kilowatt. Proof of concept, that would be very economical.

Mr. MARES. If, in fact, we prove it.

Senator MELCHER. Let's get into that. Now, you've had the coal fire facility in Tennessee, the demonstration facility at Arnold Engineering Developing Center, and then the CDIF at Butte. Then we add to that the Electric Power Research Institute inverter which was to be tested this spring. I believe that's private money, is it not?

Mr. MARES. It's from the public utilities.

Senator MELCHER. Let me contrast this for you. To provide a better method of getting the steam down into the oil holes out there in that heavy oil country near Bakersfield we can come up with some R&D money which the oil companies could come up very easily, and would come up with.

I looked at Arco's big building there next to the Bank of America in Los Angeles, and it probably costs them around $12 or $15 million to keep that building up, just to keep that one building up per year. That type of money is available for the oil companies to figure out how to get the heavy oil up.

So it is not in the same priority as some people are generating electricity for consumers, because there is a difference. The private utility companies are locked in to putting everything they do into their base rates, and they are not out there accepting small grips and grabs per company and being able to do the R&D work.

So about half of what has been done so far has actually been done by private resource money.

Mr. **Mares**. That's not my understanding. I believe a much smaller sum has been invested by the private sector.

Senator **Melcher**. Well, I've followed it now for a little more than 12 years, when we got the Office of Coal Research to increase their budget for MHD from $150,000 up to about $350,000 or $400,000. Up to that point there had been a number of millions of dollars spent on MHD research and it is practically all private and virtually none Government.

When you look at it all over the past 20 years you will find that I am about right.

Now, we've got this to the stage to where a few more years of R&D work by Government, with some contribution from the private sources, where we feel that perhaps it would be ready to go commercial late this decade and we find the Department of Energy shutting it off. They sought to shut it off last year and we insisted that it be funded. It will probably be insisted that it be funded this year.

I dare say, there is a lot of money wasted as you plan to mothball and not continue the work, and that doesn't get us anywhere. That wastes money rather than moves forward. You've got the magnet being tested in Russia, and you've got the bigger magnet at Argonne just sitting there waiting to be tested somewhere and no plans to test it.

You've got this inverter from the Electric Power Research Institute that was suppose to be tested this spring and isn't going to be tested.

We've got all this ongoing work to reach that goal of being able to go commercial. Now this won't help anybody with electric bills this year, next year, or the year after. I think what we are trying to do here and what your job is is to promote the R&D work that is going to help us at the end of this decade and into the next decade.

Mr. **Mares**. The Department and my office are working on several technologies that promote the more efficient and the more economic production of electricity through the use of fuel cells, PFB, and even supporting the combined cycle.

The proof of concept for the MHD project is very very substantial, five times what my budget is for this year. There is no way that I can recommend the continuation of that effort.

Furthermore, it is not just a few years out. It is a long time before that proof of concept will finally come to fruition. My judgment is there is no way I can continue to——

Senator **Melcher**. Wait a minute. You are giving your opinion that it is a long way out, but I would disagree.

Mr. **Mares**. I am not aware that even MHD advocates have recently said that a 200 MWe MHD proof of concept plant could be built and operating before the early 1990's. The first true commercial plants would come much later.

Senator **Melcher**. The proof of concept, using your own figures, comes out to $2,000 per kilowatt.

Mr. **Mares**. The total overall cost of proof of concept for these others that we are working on is much less, and the proof of concept is the area where the Federal Government has a potential role, but not in all cases. The projected cost through proof of concept for the other technologies that I have mentioned for is substantially less than a half billion dollars. That's an enormous amount of money.

Senator MELCHER. It's only one-half—it is less than one-half of what has been requested for nuclear this year.

Mr. MARES. But within my budget I am working within several areas that are important to develop for the more efficient use of electricity. I can't justify continuing to——

Senator MELCHER. We are not arguing that your budget is adequate.

Mr. MARES. I think it is.

Senator MELCHER. We are arguing that it is totally inadequate; your own figures started out with over $300 million and that has been reduced to $90 million.

What does a 4.8 megawatt fuel cell cost today?

Mr. MARES. I think the investment to date in that project is about $40 million. I could get you the exact numbers on the unit itself.

[The information follows:]

The cost of the manufacture and fabrication of the fuel cell facilities has been $56 million. That comes out to a cost of $11,667 per kilowatt.

Senator MELCHER. That spells out to me in pretty simple arithmatic that that's $8,000 per kilowatt.

Believe me, Mr Secretary, I'm not going to argue that you shouldn't continue. I'm just going to argue that you are neglecting an opportunity for this country the central base power generation; that if it isn't done here, it's a great disservice to the country.

I point out again, as I did in my opening statement, that Russia continues with it, Japan continues with it, and other countries are continuing with it and are doing much better than we are. Russia has some capability generating through the MHD technology and has some stuff on line. We are simply spinning our wheels if we agree with you on this, and I vigorously disagree with you. I don't want you to feel that I am discouraging you from continuing fuel cells and fluidized beds. I think that's fine. I just think that there are some blinders on the Department with regard to MHD and they are wasting money over the last couple of years by attempting to shut down the program. Clearly Congress wants it continued.

Thank you very much.

Senator DOMENICI. Do you think he knows you disagree?

Senator MELCHER. I think we established that.

Senator DOMENICI. Thank you very much.

Next we will hear from Mr. Brewer, Assistant Secretary, Nuclear Energy.

Thank you very much for patiently waiting for us, Mr. Secretary. Would you please identify those who are with you, and give me some idea as to the minimum amount of time you need to go quickly through. I have 10 minutes of questions, and we are in pretty tough shape.

STATEMENT OF HON. SHELBY T. BREWER, ASSISTANT SECRETARY, NUCLEAR ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. FRANK E. COFFMAN, DEPUTY ASSISTANT SECRETARY FOR WASTE MANAGEMENT AND FUEL CYCLE PROGRAMS; GORDON L. CHIPMAN, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR REACTOR PROGRAMS; AND WILLIAM R. VOIGT, JR., DIRECTOR, OFFICE OF URANIUM ENRICHMENT AND ASSESSMENT

Mr. BREWER. I would propose to offer a statement for the record and make about 6 or 7 minutes of oral remarks.

I am accompanied today, Senator, by, on my far left, Mr. Bill Voigt who is the director of the enrichment and assessment program; on my immediate left is Dr. Frank Coffman who is Deputy Assistant Secretary for Nuclear Waste Management; on my right is Mr. Gordon L. Chipman, Deputy Assistant Secretary for Nuclear Reactor Programs.

My responsibility includes operational programs such as enrichment which we operate like a business. It includes also long-term R&D and programs aimed at specific one-time objectives such as the breeder program. It includes programs which are in between, such as waste management.

In a moment I will tie all of this together.

Senator DOMENICI. For purposes of the young lady here, I assume those charts are a part of the testimony?

Mr. BREWER. We will submit them for the record.

There are three appropriation bills that affect my responsibilities: Energy supply R&D, the water and power bill, and the defense bill. We also have naval reactors in my area of responsibility.

I would like to turn now, Mr. Chairman, to the President's nuclear policy statement and how we have reconfigured the program in the Department of Energy to meet the objectives of that statement.

There are four fundamental ingredients to the President's statement. The first, of course, is to revitalize the light water reactor industry which, as you know, is in very desperate straits. Over 50 plants have been canceled in the past several years, and there have been no orders since 1978.

Also, waste disposal. The Federal Government has not completed its statutory responsibility to provide a system which will ultimately dispose of high-level waste. We are to accelerate that and get that job done.

As well, we are to proceed and continue with the scale-up of breeder reactor technology, and in particular, Clinch River, and finally, the linkage between all of these elements, reprocessing.

I would now like to tie these four elements together in a rather elaborate chart. I'm not going to belabor this. I will put this in the record. At the top in red we see the current light water reactor fuel cycle beginning at the far left with mining and milling, enrichment, light water reactor fuel fabrication, power production at the reactor plant. Then onsite fuel storage, prospectively offsite fuel storage and light water reactor reprocessing.

Now, everything to the left in red exists, but, however, is in a very depressed state, including, as you well know, the uranium mining industry because the light water reactor orders and the pipeline have fallen off.

Another Federal responsibility, shown in green, is the waste management system, immobilization of waste from the light water reactor reprocessing plant, and prospectively an interim storage capability. Finally, ultimate disposition in the geological repository.

Everything in blue, Mr. Chairman, is the breeder reactor system. As you know, we are in the throes of trying to get Clinch River accelerated. We are also demonstrating, or we will be demonstrating high-speed, remote-operated fuel fabrication at the SAF facility. There are two critical linkages to note here between the light water reactor system and the breeder system. One is the depleted tails stockpile. There is enough there to power this country for at least 500 or 600 years without mining anything. Beyond that we have essentially an infinite source. The other linkage is we need the light water reactor plutonium to start up the breeder economy.

This concludes my dissertation on the linkage and the total response to the President's nuclear policy statement. I would like to summarize the budget structure.

Senator **Domenici**. This is your prepared statement? We will make that part of the record. If we have any questions, or the subcommittee members have any, we will get them to you as soon as possible. I think we are on a short time fuse, so if you could give us the answer as soon as possible, we would appreciate it.

I don't want to cut you too short.

Mr. **Brewer**. That concludes my remarks at this point with one simple statement. The nuclear budget is down from fiscal year 1982 as are other budgets in the Department of Energy; contrary to popular notion, the nuclear budget is not the big hog at the trough. We have been reduced as well. We have trimmed out the fat, and focused it on specific large objectives that the President has identified.

That concludes my statement, Mr. Chairman. I and my staff would be happy to answer your questions.

[The prepared statement of Mr. Brewer follows:]

Statement of Shelby T. Brewer
Assistant Secretary for Nuclear Energy
Department of Energy
Before the
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
U.S. Senate
March 17, 1982

Mr. Chairman and Members of the Committee, I am pleased to appear before you to discuss our programs for fission energy. Today I will provide you with an overview of all our programs and then discuss in some detail the programs for Converter Reactor Systems, Advanced Nuclear Systems, Commercial Waste Management, the Nuclear Fuel Cycle, Remedial Actions, and Uranium Enrichment. It is my understanding that I will be discussing our programs for Breeder Reactor Systems at some future date.

The fission energy funding request for FY 1983 is $1,017 million in budget authority, compared to $1,089 million in FY 1982. Distribution of the funds among the program elements is as follows:

	FY 1982	FY 1983
	(in millions)	
Converter Reactor Systems	96	32
Breeder Reactor Systems	647	577
Advanced Nuclear Systems	38	31
Commercial Waste Management	210	81
Nuclear Waste Disposal Fund	--	185 1/
Nuclear Fuel Cycle	53	59
Remedial Actions	43	50
Uranium Enrichment	1,709	1,930 2/
Advanced Isotope Separation	86	34 2/
Uranium Resource Assessment	10	3 2/

1/ Legislation authorizing the Waste Disposal Fund is not included in this request for appropriations.

2/ Offset by projected revenues of $2,033 million.

Mr. Chairman, today nuclear energy is providing approximately 12 percent of our country's total electrical supply. This year it is projected to become the second largest generator of electricity, surpassed only by coal. By 1990, as additional plants in the pipeline begin operation, its contribution will increase to between 22 and 25 percent. This is an impressive performance, but I am convinced that nuclear energy can and should contribute far more to our future energy security. The nuclear option is capable of providing hundreds of years of economic electrical power, independent of foreign energy sources, while allowing us to conserve our fossil fuel for other critical applications. Achievement of this goal is predicated on the establishment of a fully integrated fuel cycle and power generation system. The essential elements of this system include a smoothly functioning light water reactor industry, a completed fuel cycle including effective reprocessing and waste management systems, and the timely introduction of the breeder reactor.

On October 8th of last year, President Reagan announced a revised nuclear policy that recognizes both the potential of nuclear energy and the impediments currently restricting its full use. To remove these barriers and allow nuclear power to compete, free of constraint, in the marketplace, several major policy initiatives were announced. They include regulatory and licensing reform, lifting of the ban on commercial reprocessing, accelerated deployment of Federal waste management capabilities, and resumption of breeder development, including completion of the Clinch River Breeder Reactor (CRBR). These directives provide the major thrust of the programs that I will discuss today.

At my confirmation hearing last summer, I pledged my intention of using a "management-by-objective" approach in the planning and execution of our nuclear programs. Adhering closely to this principle, we have directed our research and development to the few large national objectives with which we have been charged. We believe strongly that the resulting, sharply focused programs are both technically sound and cost effective. Our FY 1983 budget proposal eliminates program elements that are not directly related to our major objectives. The remaining elements have been carefully structured to insure maximum effectiveness. As a result, our nuclear activities other than waste management are reduced 16 percent relative to the FY 1982 appropriations. This represents a reduction of 31 percent for programs other than CRBR.

In comparing the budget requests for the individual programs, one distinction should be kept in mind. The amount requested does not necessarily reflect the relative importance of the program. For example, as you will note, the request for our Light Water Reactor Programs is relatively quite small, showing a sizeable decrease from the FY 1982 request. Without doubt, we consider resolution of the issues facing the LWR of primary importance and, indeed, prerequisite to deployment of advanced nuclear options such as the breeder. The reason for the comparatively low request is that LWR technology has been developed, demonstrated, and in use commercially for 25 years.

The need for continued Federal involvement pertains generally to the resolution of regulatory and institutional concerns, with R&D limited to specialized areas such as our TMI cleanup activities. This accident has provided a unique opportunity to obtain important R&D data of generic value to the improved safety of LWRs. Federal Government participation in the cleanup is limited to those tasks that are of broad national benefit or that relate to the Federal responsibilities, under the Atomic Energy Act of 1954, to ensure safe disposal of nuclear waste.

In addition to our research to improve LWR technology, we are responding to the President's policy directive by participating in task forces to identify and alleviate the institutional ills currently confronting the nuclear option. We expect to make recommendations in the near future regarding licensing and regulatory reform and improvement of the climate for nuclear investment.

A final near-term activity that is critical to the continued viability of nuclear power is the establishment of an effective nuclear waste management system. As you know, the past 10 years have witnessed a myriad of paper studies resulting in numerous policy and program redirections, but we have yet to demonstrate the ability to store and dispose of high-level nuclear waste. The lack of decisive action by the Federal Government has allowed this issue to develop into a problem of national concern.

Despite past indecision, several facts are clear. First, nuclear waste is a very real and present phenomenon. Second, we have available technically adequate means for handling this waste. And, third, the longer we allow political vacillations to delay the establishment of an effective waste management system, the greater will be the level of public concern.

In response to the President's call to break these chains of indecision, we have initiated an ambitious, results-oriented nuclear waste program. We are proposing more aggressive schedules for building a test and evaluation facility and for construction of the first licensed waste respository. We have in place a sound technology base--we must now make choices and take action. The number and scope of nuclear waste bills presently under consideration in the Congress indicates that this body, too, is determined that a safe, efficient system be operative as soon as possible.

We are closely monitoring the progress of nuclear waste legislation. One provision that we consider imperative is the establishment of a user-derived fund for major capital expenditures for waste management services, as recommended in our budget. Such a fund would allow those who are benefitting from the electricity generated by nuclear power to pay for the total costs associated with its production. It also would provide the program with the necessary resources to develop and operate repositories without competing for limited funds in the Federal budget. In exchange for upfront financing, we believe the legislation should provide that the Government will agree to assume responsibility for the utilities spent fuel (or high-level waste when reprocessing is available) at some fixed future point.

In my opening remarks I stated that a fully integrated fuel cycle is essential to the complete realization of nuclear fission's potential. Along with other advanced nuclear countries, we recognize the benefits of reprocessing spent fuel and preserving access to this residual energy resource. Additional incentives for developing a domestic reprocessing capability include improved waste disposal characteristics, relief of the spent fuel storage congestion problem, and provision of the plutonium inventory required for breeder reactor demonstration and deployment.

We have been instructed by the President to identify regulatory barriers to commercial reprocessing and to develop recommendations on how to create a more favorable climate for private reprocessing efforts. In carrying out this directive, we have found not only regulatory barriers, but also a number of institutional and economic uncertainties that are impediments to commercial reprocessing. We expect to provide specific recommendations within the next several months for Government actions that will allow the private sector to move forward once again. We remain optimistic that if the Government does its part, the private sector can and will provide a domestic reprocessing service that will restore U.S. leadership, credibility and influence in this critical area.

The final element of an integrated fuel cycle and power generation system is the breeder reactor. The vast potential of the breeder concept was recognized in the mid-1940's by the early pioneers in nuclear fission research. It has been U.S. nuclear development policy from the outset to secure an economic and deployable breeder option for whenever it might be needed. The LWR, resting largely on technology inherited from the naval program, was deployed in the early 1960's and thus became an intermediate step to a breeder economy. It was planned that, ultimately, plutonium stockpiles from reprocessed LWR fuel and depleted tails from enrichment plant operation would launch a breeder economy. The implementation strategy that emerged over the years established a sequence of breeder reactor projects of increasing power rating as the central path of the U.S. breeder research and development program. This plant sequence would provide the organizing principle and schedule for all effort in the program. Prior to

1977, when President Carter deferred breeder development and reprocessing, the planned project sequence was:

- The Experimental Breeder Reactor (EBR-II)--on line in 1964;
- Fast Flux Test Facility (FFTF)--scheduled to be on line in 1980;
- Clinch River Breeder Reactor (CRBR)--scheduled to be on line in 1983;
- A large prototype plant--scheduled to be on line in 1988.

The President, last October, recognized the importance that this breeder technology holds for our future energy security and directed the completion of the Clinch River Breeder Reactor Project. He also recognized the viability of advancing commercial reactor development through progressive scaleup. The approach we are using for CRBR employs not only a scaleup in plant size but a corresponding scaleup in major sodium system components. Research and development in generic breeder system technology, which provides necessary support to plant projects, completes the coordinated strategy. We believe strongly that this approach has invaluable implications for safety, plant reliability, and ultimate plant effectiveness. That industry agrees is evidenced by the significant commitment of 753 electrical utilities, grouped under the Breeder Reactor Corporation, in pledging $257 million to support design, construction, and operation of the Clinch River Reactor.

The decision 5 years ago to defer breeder demonstration has, of course, had a severe impact on CRBR. The effect of the policy debate during the Carter Administration has added approximately $850 million to the cost of the project. More than a day-for-a-day schedule slippage has occurred: in 1977, criticality was scheduled for 1983; at the beginning of the Reagan Administration last year, the reference criticality date was 1990. During my confirmation hearing I pledged to rebaseline CRBR with an aim toward streamlining the project and accelerating the schedule. We are currently seeking methods of trimming the construction time, including the resequencing of construction tasks.

Although the CRBR deferral decision made it impossible to achieve many of our project milestones, efforts in areas not constrained produced notable results. As of January 1, 96 percent of the research and development necessary to build CRBR had been completed, as had 87 percent of the engineering and 60 percent of the equipment procurement.

The next step beyond the CRBR, construction of a large developmental plant, will be primarily the responsibility of the private sector. Current Government involvement is limited to research and development and institutional planning to permit private sector utilization of Government-sponsored efforts on the LMFBR. We believe this is consistent with the Administration's philosophy that the Federal Government should develop long-range, high-risk technology of significant potential national benefit.

A very important lesson that we learned from LWR commercialization is that development of reactor technology must be accompanied by development of supporting fuel cycle technology. This means that to support commercially deployable breeder reactors, we must also develop safe technology for the back end of the fuel cycle.

Accordingly, our fuel cycle R&D program is focused on developing breeder fuel fabrication and reprocessing as part of the overall breeder R&D program. The objective is to develop the technology to a stage that would represent an acceptable economic risk to the private sector. Ultimately, industry must make the choices and bear the responsibility for all aspects of commercial breeder deployment.

Resumption of a leadership role in advanced technologies such as the breeder and reprocessing will enhance our influence in international technical, political, and economic developments as well as our ability to influence world nonproliferation strategies. The availability of advanced technology coupled with renewed efforts to demonstrate the attractiveness of U.S. products on the world marketing scene should substantially increase our viability in foreign commerce.

A key element in our efforts to firmly establish the United States as a reliable supplier of nuclear fuel services is our Uranium Enrichment Program. As you know, the United States presently enriches uranium to the desired U-235 product assay levels in three gaseous diffusion plants located at Oak Ridge, Tennessee; Portsmouth, Ohio; and Paducah, Kentucky. To operate these plants efficiently, we have projected future enrichment requirements to determine the appropriate operating level to meet these requirements. These projections indicate that capacity beyond what is currently available in the gaseous diffusion complex will be required in the 1990's.

Based on the sound technological base which has been developed over the last 20 years, gaseous centrifuge technology is considered the most economical and efficient choice for producing this additional capacity in the required timeframe. In addition to providing separative work at a significantly lower cost than is currently possible, the centifuge process uses but one-twentieth of the energy that gaseous diffusion consumes. Consequently, we are constructing a Gas Centrifuge Enrichment Plant (GCEP) at Portsmouth, Ohio. Construction progress has been excellent. We are on schedule and the total estimated cost, adjusted for escalation, has remained constant.

The enrichment of uranium in the centrifuge plant will begin in 1988 with a capacity of 2.2 million SWU per year available in 1989. Additional production capacity will be added as demand for enrichment services warrants or as economics justify the substitution of gas centrifuge for the more energy-intensive gaseous diffusion. Full production from the 8-building plant is scheduled in 1994.

An advanced enrichment technology, the Advanced Isotope Separation (AIS) process, is being developed. AIS offers the potential advantage of further reductions in capital cost and energy consumption, but it does not enjoy the same technological base as the centrifuge option. When successfully developed, the AIS process could provide new enrichment capacity in the mid-to-late 1990's. Selection of a single process for engineering development from among the three candidate processes will occur in FY 1982 and progress toward a development/demonstration module will continue in FY 1983.

As you know, revenues are received from the sales of enrichment services to domestic and foreign customers. For FY 1983, we estimate these to be over $2 billion. These revenues will more than offset the requirement for appropriations to cover our enrichment activities.

Based on the viability of our operations, there have been suggestions over the years that enrichment activities be transferred to the private sector. We are currently evaluating that option and identifying appropriate procedures should a decision be made to transfer enrichment activities to private industry.

I will now review the objectives, strategies, and status of the programs being discussed today.

CONVERTER REACTOR SYSTEMS

The overall objective of the Converter Reactor Systems program is to enhance the utilization of domestic energy resources. This program will consist of three major elements: Light Water Reactor Systems, Three Mile Island Activities, and Program Direction.

The total funding request for Converter Reactor Systems in FY 1983 is $32.0 million compared to $96.3 million in FY 1982. This request is broken down by program element as follows:

	(B/A in Millions)	
	FY 1982	FY 1983
Light Water Reactor Systems	22.7	4.0
Three Mile Island Activities	32.8	27.0
Advanced Reactor Systems	4.1	0
High Temperature Reactors	35.3	0
Program Direction	1.4	1.0

Light Water Reactor (LWR) Systems

When electric demand dictates, additional nuclear capacity will be sought provided that institutional and financial obstacles are overcome. These obstacles are difficulties in capital formation by utilities, instability of regulatory process, and public perception of nuclear power. Certainly, there is no intrinsic reason why it should take between 10 and 15 years to bring nuclear plants into operation in the United States, when plants in France and Japan can be licensed and constructed in about 5-7 years. One correctable reason this condition exists in the United States is the uncertainty that a utility must face throughout the entire regulatory process, including the construction period and even after plant operation begins. The utilities and their investors simply cannot cope with the resulting uncertainty and significant costs over a 10-15 year time period. In addition, it impacts the public's confidence in perceptions in the ability to provide reliable, economic, and safe nuclear power. The Vice President's Task Force on Regulatory Reform offers an opportunity to correct much of this problem.

The general problem facing the utilities related to formation of capital for projects which offer lower life-cycle energy costs is not unique to the nuclear industry; it also impacts other capital intensive options such as coal. Allowed or realized rates of return are simply not commensurate with utility needs for capital to build new plants. At issue is the financial viability of the electric utilities--an issue which goes to the heart of our economic security. The President's Economic Recovery

Plan and his regulatory reform objectives strive to create an investment environment more favorable to utility capital formation. Supporting the Administration's efforts, the goals of the Agency are:

- Develop the necessary information supporting the Vice President's Task Force on Regulatory Reform.
- Make available Agency facilities to conduct safety research needed to improve overall safety and to reduce costly nonproductive requirements.
- Provide information and impetus to industry efforts to improve design, manufacturing, construction, and testing practices.
- Serve as the Administration's focal point for the support of nuclear power developments; provide factual information to the industry, financial community, and the general public.
- Gather information, perform R&D, and provide technology support to achieve safe and more expeditious Three Mile Island recovery as appropriate to the public interest.

Two major subprograms in Light Water Reactor Systems are LWR Safety and LWR Extended Burnup.

LWR Safety

The objective of the LWR Safety Subprogram is to formulate, coordinate, and conduct R&D to improve reactor safety and support revitalization of the LWR energy option. To achieve this objective, the Department will coordinate the development and implementation of a DOE/NRC/Industry cooperative program that:

A. Defines the institutional and technological issues of priority in achieving these goals; and

B. Identifies the efforts required to resolve these issues.

In response to Presidential and Congressional mandates, including Public Law 96-567 (Nuclear Safety Research, Development, and Demonstration Act of 1980) and to meet the objectives of the Agency program, a comprehensive LWR Safety program, in cooperation with industry, NRC, national laboratories, other Government agencies, and foreign programs, is being conducted. A key effort in this program is the development of a systematic and integrated approach to LWR safety.

As discussed in our response to Congress relative to Public Law 96-567, this program is divided into two phases--a program definition phase and a program implementation phase. In order to define program needs and priorities we are utilizing working groups composed of representatives from DOE, NRC, industry, and national laboratories to assist the Agency in both the program definition and program implementation phases. The Agency has convened 8 of these working groups and their membership and schedule of activities have been provided to Congress in our response to Public Law 96-567.

Major accomplishments in FY 1982 will include:

- Submittal of the three specific studies required by Public Law 96-567 to the Congress by the Secretary on January 29, 1982.
    - A Comprehensive Program Management Plan.
    - A study of the need and feasibility of a National Reactor Engineering Simulator.
    - A study of the sufficiency of U.S. efforts to provide specially trained operators for nuclear plants.
- Completion of development of regulatory reform recommendations.
- Completion of restructuring of the program to meet the program's objectives and thereby be compatible with the needs of NRC and the industry.

The restructured LWR Safety Subprogram supports the goal of improving safety and revitalizing the LWR industry through the following planned activities in Fiscal Year 1983:

1. coordinate and maintain the comprehensive LWR Safety program plan as directed in Public Law 96-567.
2. complete efforts to identify and prioritize safety research requirements.
3. continue efforts to reduce unnecessary technical regulatory burdens.

LWR Extended Burnup

The principal purpose in extending the burnup of LWR fuel is to reduce the generation rate of spent fuel and thereby reduce spent fuel storage and reprocessing requirements. Extended burnup can improve fuel cycle economics and the utilization of uranium resources.

The accomplishments of this subprogram to date have included proof of the capability of LWR fuel to achieve excellent extensions of burnup. Fuel from each of the five U.S. fuel vendors, equivalent to twenty-two fuel assemblies, has been irradiated in seven commercial light water reactors, and selected assemblies have achieved burnups up to 47,000 megawatt-days per ton (MWd/t), a value representing almost two-thirds of the burnup extension being sought. Advanced high burnup fuels designed to achieve the full program goal burnup extensions have been fabricated, and their irradiation has been initiated in two commercial reactors. The Duke Power Company has ordered reload fuel of moderately extended burnup as a direct result of this subprogram, and other utilities are evaluating similar orders. A pure zirconium lined cladding that is resistant to pellet-cladding interaction (PCI) failures, an issue that needs to be resolved prior to broad utility acceptance of burnup extensions, has been developed. Resolution of PCI also contributes significantly to improvement of fuel integrity, plant capacity factors, and of the load following capability of LWR's. A large-scale verification of this remedy, using 144 assemblies incorporating the remedy cladding, has been initiated in a commercial light water reactor.

In prior years, the overall strategy for this subprogram (formerly called uranium utilization) had been to accomplish LWR fuel improvements through multiple cost-shared projects with industry aimed at the development and in-plant verification of the improved technology. This strategy had enhanced and accelerated the level of R&D, had encouraged commercial demonstration and utilization of improved technologies, and had kept the Federal role and cost low. These efforts involved eleven electric utilities, all five nuclear fuel fabricators, two utility-supported organizations sponsoring research and development, and a larger number of European and Japanese organizations.

In FY 1983 the subprogram will be focused to include proving the performance of a single extended burnup fuel design up to established goal burnups, obtaining licensing data to support that and other extended burnup design, and developing other necessary supporting technology. This focusing will result in a single utility/fuel fabricator team becoming the principal contractor for the subprogram. Others in the industry may then follow in extended burnup development and implementation through the natural competitive forces of the marketplace. Technology development and licensing data needs in support of extended burnup are emphasizing PCI remedies and fission gas release data. Of two major contracts for verifying PCI remedies, one will be completed. Several internationally sponsored projects to which we are contributing moderate percentages of their cost are obtaining fission gas release data needed in support of extended burnup fuel design, are determining the PCI-related performance of current and improved fuel designs, and are verifying the capability of extended burnup fuel to accommodate licensing-basis transients.

Three Mile Island (TMI) Activities

The overall goal of the Agency's Three Mile Island activities has been to develop and improve measures for enhancing safety and reliability of nuclear powerplants and to improve the capability to decontaminate nuclear powerplants. To accomplish this goal, we are pursuing a program of carefully examining and evaluating the TMI-2 accident and the response of the nuclear powerplant components and systems to accidents.

In consonance with the Administration's policy of placing responsibility for commercial nuclear power activities in the private sector, the Agency's TMI program is limited to necessary research and development only. Although responsibility for the costs of TMI cleanup is with the owner, the General Public Utilities (GPU) Company, some of the Agency's TMI research activities in FY 1983, such as in-situ inspection of the reactor core, are expected to have indirect benefits to GPU and to offset some of their cleanup costs. Such activities will only be conducted if they offer the opportunity to obtain significant generic research information.

In accordance with a Memorandum of Understanding between the Agency and the Nuclear Regulatory Commission, the Agency will acquire radioactive waste from TMI for research and development, and disposal.

The TMI activity has two major program elements: (1) a TMI Reactor Evaluation and Waste Immobilization Program that was initiated in FY 1982 and (2) a TMI Data Acquisition Program that began in FY 1980.

Waste Immobilization and Reactor Evaluation

The objectives of this subprogram are: (1) to examine the TMI-2 reactor and core components and to conduct research and development associated with the reactor defueling to provide data for evaluation of licensing criteria and requirements, analysis of causes and consequences of accidents, and, improvement of the reliability of the design and operation of LWR's, and (2) to conduct research and development on immobilization of abnormal reactor waste products. The $17 million of the funding request to be applied to this program in FY 1983 will continue the efforts in both of these areas.

The waste management and immobilization activities will initially be focused on an effort to demonstrate the feasibility of vitrifying zeolite ion exchange materials. The program will have demonstrated this feasibility in FY 1982. In addition, the majority of the Submerged Demineralizer System liners and the EPICOR-II liners will be shipped from TMI to Government facilities for R&D purposes.

Beginning in FY 1983, this program will focus on other techniques for the treatment of abnormal wastes produced at TMI, including alternative immobilization concepts, confidence testing, and long term sample observation to provide a more extensive data base. The knowledge gained from this program will contribute substantially to the technology for processing and disposing of unique waste forms resulting from commercial nuclear powerplant abnormal operations and accidents.

The reactor evaluation activities include the examination, removal, and disposition of the reactor core and internals;

the development of the special systems, equipment, facilities, and processes needed to accomplish these tasks; and the conduct of supporting onsite and offsite fuel examinations, tests, and evaluations. Through-the-head visual examination of accessible parts of the reactor upper internals and core will be accomplished prior to defueling.

In FY 1983 preparations will be made for reactor head and plenum removal and defueling. The purpose of this activity is to obtain data and information on the condition of the reactor core and other internal components, to conduct the development needed for a thorough examination, and to effectively complete the defueling in as low as practical radiation environment. In addition, it is planned to perform offsite examinations of the fuel and debris to characterize the accident effects.

The knowledge gained from this program will provide data required for evaluating present licensing criteria and requirements; developing future licensing criteria; assessing and developing computer models used to analyze the course and consequences of severe accidents and means to mitigate the effects of such accidents; and evaluating improvements to reactor design, operation, and maintenance.

Data Acquisition Program

The objective of this subprogram is to obtain important R&D data that are of generic value to the safety of light water reactors.

This element of the TMI activities is being implemented in accordance with a Memorandum of Understanding signed by the Nuclear Regulatory Commission (NRC), Electric Power Research Institute (EPRI), and General Public Utilities (GPU). The efforts of GPU are aimed primarily at plant cleanup and recovery. The Agency has developed a program work scope that will obtain information that would not normally be obtained from the cleanup efforts required. The Agency's program is being conducted to avoid delaying the GPU cleanup schedule.

The Agency and EPRI are sharing responsibility for portions of this R&D program scope. Specifically, the Agency is funding data gathering, research and development, and information transfer in the following major areas: instrumentation and electrical equipment survivability; behavior of radioactive products; data system and specimen archiving; and offsite fuel debris examination. EPRI has similar responsibility for mechanical and structural component reliability, pressure boundary characterization, and decontamination and dose reduction associated with the primary coolant system.

The Agency has established a Technical Integration Office at TMI to manage Government activities, with EG&G Idaho as lead contractor. The technical information being obtained is being provided to the nuclear industry and the NRC through means of reports and seminars.

Some of the recent accomplishments of this subprogram include:

1. Eight electrical instruments were removed from the containment and fifteen electrical components were tested in-situ. Failure modes and effects were assessed and generic design and installation changes were suggested. Several manufacturers of electrical instruments are modifying designs based on TMI program suggestions.

2. Over 400 radioactive samples were analyzed and an initial effort at a mass balance was undertaken.

3. More than 250 detailed photographs were taken in the containment as part of the effort to assess the damage in the reactor building. All vertical surfaces appear to have little or no damage. This assessment leads one to believe decontamination of these surfaces will not be a significant problem. Additional data characterizing the hydrogen burn has been obtained; this provides significant input to an understanding of the hydrogen event. This should impact NRC rulemakings.

4. An EPICOR-II resin liner that was used to clean contaminated water in the TMI-2 auxiliary building was examined at Battelle Columbus Laboratory. The remaining 49 EPICOR-II liners will require gas venting prior to shipment due to combustible mixture of gases being generated in-situ. The TMI program has designed and fabricated a device to accomplish this operation based on data generated by the TMI program at Battelle.

5. A seminar was held with representatives of the United States and foreign nuclear utility industry to describe the status and results of the TMI program.

6. An effort to design and fabricate a high integrity container suitable for disposal of EPICOR-II resin liners was initiated.

The $10 million of the funding request to be applied to this program in FY 1983 will continue the data gathering activities previously described, focusing on additional examination of electrical equipment, radionuclide analysis of samples removed from containment, and developing fuel and core examination techniques.

The electrical equipment information will be used to upgrade qualification standards, regulatory guides, and operating and maintenance standards in order to improve operation of nuclear powerplants during transients. The data on radioactive samples will be valuable in assessing the existing models for fission product release that are used in nuclear powerplant licensing.

ADVANCED NUCLEAR SYSTEMS

The Advanced Nuclear Systems program is responsible for the development and delivery of nuclear power sources for U.S. military and civilian space and terrestrial applications and is responsible for the assessment and maintenance of those nuclear energy sources consistent with the Agency's health and safety requirements. In FY 1983, the activities of the Advanced Nuclear Systems have been narrowed to the major program element dealing with space applications of nuclear power sources. The major undertaking will continue to be the development of the nuclear isotope power generators for use on the NASA Galileo spacecraft planned for launch in 1985, the NASA/European Space Agency (ESA) International Solar Polar spacecraft planned for launch in 1986, and the Space Reactor Technology program (SP-100), initiated in FY 1982 in cooperation with NASA. A previous major program element, Advanced Systems Evaluation, is being phased out to support overall efforts to reduce Federal budgets. Furthermore, beginning in FY 1982 responsibility for the terrestrial applications efforts on the Beneficial Uses of Radioisotopes has been transferred to Defense Waste Management.

The budget request for the Space Applications activity is shown in the following table:

	(B/A in Millions)	
	FY 1982	FY 1983
Flight Systems Development	10.9	14.2
Flight Systems Support	23.0	15.1
Terrestrial Applications	2.5	0
Program Direction	1.2	1.3

Flight Systems Development

This subprogram element includes the design, development, fabrication, and assembly of the isotope space power converter subsystems for the NASA Galileo and NASA/ESA International Solar Polar spacecraft. The isotope qualification converter and several flight converters planned for shipment from General Electric, Valley Forge, Pennsylvania, to the Mound Facility, Miamisburg, Ohio, will be supported by this subprogram element throughout the flight acceptance and qualifiction levels of tests at Mound Facility. The Updated Safety Analysis Reports for both missions are planned to be published. We have initiated discussions with NASA to expand our reimbursable work to include the qualification and spare flight units.

As currently programmed, the Space Reactor Technology Program (SP-100) will be continued in collaboration with NASA. Coordination with NASA and DARPA is now underway with a view to establishing an expanded tri-agency program (DOE, NASA, and DOD) with the DOE as the lead agency responsible for technology and development of the space reactor subsystem. Experimental work to demonstrate the technology readiness of the reactor core heat pipe heat transfer system, material characterization and compatibility, irradiation component testing, and reactor control activities will be pursued. Current space reactor component attributes are targeted for a power system at the 100 kW(e) level in the 1800 kg to 2500 kg weight range. Overall system performance characteristics are aimed toward NASA and DOD missions in the 1990's.

Flight Systems Support

This subprogram element supports fuel form production, encapsulation, heat source component manufacturing and assembly, environmental testing of the fueled flight units, and the overall independent safety and safety testing activities. In FY 1983, a significant manufacturing and testing program must be pursued both to meet the tight delivery schedules and the rigorous quality and safety requirements of the program. Iridium blanks fabricated at the Oak Ridge National Laboratory will be provided to the Mound Facility where the iridium is formed into fuel capsule containers. The Savannah River Plant will manufacture 63-watt thermal pellets of plutonium-238 and encapsulate them into the iridium containers provided by the Mound Facility.

Graphitic heat source parts will be procured, fabricated, and assembled for final installation into the thermoelectric converter hardware by Mound Facility staff. Safety analyses and safety testing will be conducted on representative flight isotope hardware components to assess the safety margin of the system by the Los Alamos National Laboratory.

Certain ongoing activities will not be conducted beginning in FY 1983. The independent technical and quality assurance efforts, which support both the flight development and research work, will be phased out. Also, reduction of fuel form production and encapsulation operations at Savannah River Plant is under consideration, in addition to the reduction of assembly and testing operations of flight fueled units at the Mound Facility, and converter fabrication work at General Electric, Valley Forge, Pennsylvania. In addition, the advanced modular isotope generator technology program will not be continued.

We are aware of the House Science and Technology Committee's desire to have the user agencies, such as NASA, reimburse the Agency for hardware units, such as the qualification power unit and the flight spare unit. As you know, NASA currently plans to reimburse the Agency for all flight units delivered in the Galileo and Solar Polar programs. This is a departure from previous practice wherein the Agency provided the first flight unit and flight spare unit to NASA. NASA subsequently reimbursed the Agency for all follow-on units. As I previously indicated, we have initiated discussions with NASA as directed by the Congress.

COMMERCIAL WASTE MANAGEMENT PROGRAM

The objective of the Commercial Waste Management Program is to plan, develop, and implement the technology and provide the facilities for terminal isolation necessary for the long-term management and disposal of high-level and transuranic radioactive wastes produced in the civilian sector primarily from the production of electricity. The budget request for FY 1983 is $80.5 million, (supplemented by the cited fund of $185 million) as compared to $210 million in FY 1982. Subprogram elements include: Terminal Isolation, Waste Systems Technology, and the West Valley Demonstration Project.

o Terminal Isolation. This activity consists of generic research and development and project-specific efforts leading to the site selection, design, licensing, construction, and operation of high level waste repositories.

The current overall program strategy is to identify three candidate geologic repository sites at which construction of exploratory shafts to depth will begin in CY 1983, to be completed by CY 1985. The three locations will likely be: in basalt flows on the Hanford Site; in welded volcanic tuff on the Nevada Test Site (NTS); and in a salt formation site to be determined in CY 1983. One of the three sites will be selected for the development of a Test and Evaluation (T&E) Facility. This decision is currently scheduled for CY 1985.

Parallel work on detailed site characterization, necessary before a decision can be made on determining the site or sites to be used for a full-scale licensed repository, will continue at all three sites. A license application for the first repository is scheduled to be submitted to NRC by 1988, with earliest operation estimated to begin in 1998. The repository would be capable of accepting spent fuel in addition to solidified high-level and transuranic waste.

The T&E Facility will provide experience and verification of waste emplacement technology. The Facility will be designed for the placement of up to two to three hundred packages of high-level waste which will be completely monitored, and designed for retrieval. Equipment for handling large quantities of waste packages will be evaluated. This experience will assist in the licensing of repositories whether or not the first repository is located at the site of the T&E Facility. Further, it will demonstrate on a practical basis that high-level radioactive wastes can be handled and stored safely.

I would now like to briefly describe our accomplishments and projected activities for FY 1982 and our proposed terminal isolation activities at the requested budget level for FY 1983.

In FY 1982, we will initiate drilling of preliminary boreholes at the salt locations to allow a CY 1983 exploratory shaft site selection for salt. Site characterization work at NTS will allow for an early FY 1983 decision on the site and horizon selection for the tuff exploratory shaft. The exploratory shaft location on the Hanford Site has been identified and confirmatory drilling of boreholes is now proceeding. Technology development efforts include initiating preliminary design of salt, basalt, tuff waste packages, and accelerated barrier materials testing. Conceptual design studies of the T&E Facility will also be initiated in FY 1982.

At the $50.4 million requested funding level in FY 1983 for generic R&D, the terminal isolation program will continue the development of technologies, such as repository sealing, transportation, and performance assessment modeling generic to the geologic media being investigated. Such activities are necessary to support repository design, licensing, construction, operation, and decommissioning. Cooperative activities with other countries will be maintained to foster developments and exchange technology on waste disposal. Related testing continues with Sweden, the Federal Republic of Germany, and Canada on a bilateral basis. Also included is the continued evaluation of the technical and environmental feasibility of subseabed disposal.

We are also requesting $185.0 million in borrowing authority to fund the project-specific activities in FY 1983 until utility fees are available. This funding will allow the construction of exploratory shafts in basalt at the Hanford Site and in tuff at NTS to be initiated in CY 1983, and for land acquisition, design, and long-lead procurements leading to a late CY 1983 construction start of the exploratory shaft in salt at a site identified in CY 1983. The funding would also provide for a very limited continuation of a nationwide screening for additional sites necessary for a system of regionally-based repositories. Preliminary design of waste packages in salt, basalt, and tuff will be completed, and scale testing of these package systems will be initiated. Design studies of the T&E Facility will continue in FY 1983. Other site-specific technology development, such as repository designs for tuff, host rock thermal-mechanical modeling, and hard rock mining equipment development, will be conducted also in FY 1983.

- The Waste Systems Technology Program, with a FY 1983 funding request of $11.4 million, encompasses the following tasks:

Federal/State interactions

This task would provide funds in FY 1983 to allow potentially affected States to participate in the planning and implementation of the site qualification and selection program for mined geologic repositories. This participation is essential in facilitating an understanding at the State level of the issues associated with repository siting and in encouraging confidence that our program adequately addresses the issues.

Supporting studies and evaluations

This task supports the nuclear waste and fuel cycle program in the areas of collection and dissemination of information on international programs; the review of technical programs by the National Academy of Sciences; and the independent assessment of technical and institutional issues.

Low level waste technology

The objectives of this activity are to facilitate the establishment of a reliable system for treatment and disposal of commercial low-level waste (LLW), to facilitate the formation of regional compacts, to transfer improved technology to the private sector, and to foster cooperative technology development demonstrations with the States and industry. Assistance in the timely development of regional LLW disposal sites will include comprehensive planning and other support, the assessment of waste generation, waste treatment analyses, site screening and selection methodologies, characterization studies and the demonstration of improved technologies. The technical program will focus in FY 1983 on waste form and volume reduction processes, radionuclide migration, and disposal site stabilization.

- West Valley Demonstration Project. The objective of the West Valley Demonstration Project is to carry out a high-level radioactive waste solidification demonstration project at the Western New York Nuclear Service Center near West Valley, New York, under the provisions of Public Law 96-368, the "West Valley Demonstration Project Act." The project will demonstrate the technology for solidification and preparation for permanent disposal of approximately 600,000 gallons of high level wastes from nuclear fuel reprocessing. It will also provide experience in the decontamination and decommissioning of nuclear fuel cycle facilities and operational experience on the removal and handling of stored waste, and will demonstrate technologies for the decontamination and decommissioning of high-level waste storage tanks.

The removal of high level waste from the storage tanks at West Valley is made difficult by restricted access to the inside of the tanks. Cleanup is further impeded by the variable composition of the waste and a gridwork structure in the bottom of the tank that interrupts clear access of rinsing and pumping devices. One of the first activities will be to develop the tooling and sampling devices for working through the existing access openings and to characterize the waste and design a removal program. We expect that special techniques of manipulation and special tools for sluicing material from the bottom of the tank will be a part of the development required for the project.

The FY 1983 funding request for the project is $15.4 million. Activity will emphasize the establishment of the technical, cost, and schedule baselines for carrying out the project, and the operation, maintenance, and upgrading of the facilities at the West Valley Center. A high priority is being assigned to verification of waste solidification equipment and performance of the solidified waste product, design of the waste removal and processing systems, and decontamination of the facilities for reuse and subsequent final decommissioning.

On November 3, 1980, the Department of Energy and the State of New York signed a cooperative agreement establishing the framework for the implementation of the Project. In July 1981, the Department issued a draft environmental impact statement. Public hearings on the draft EIS and project were held in West Valley on September 26, 1981. The final statement and record of decision are scheduled to be issued this summer. On September 18, 1981, the Department and the State amended the cooperative agreement to resolve some ambiguities contained in the initial agreement. The resolution of these issues permits us to move forward in a cost-effective manner.

On September 23, 1981, the Department and the Nuclear Regulatory Commission (NRC) completed a Memorandum of Understanding as required by the Act. This agreement established arrangements for NRC review and consultation on Project activities, especially as they relate to plans for waste removal, solidification and preparation for disposal, as well as ultimate decontamination and decommissioning. NRC will also be consulted on waste forms, containers, safety analysis and other related reports, and will have access to the site to monitor project activities for the purpose of further assuring the public health and safety. On September 30, 1981, the NRC issued a license amendment to permit licensees to transfer possession of the West Valley facility to the Department. This transfer took place on February 25, 1982.

NUCLEAR FUEL CYCLE PROGRAM

The Nuclear Fuel Cycle Program includes technology for the safe and economic closing of the back-end of the light water reactor (LWR) nuclear fuel cycle, R&D on the breeder fuel cycle, and the development of waste forms that would meet requirements for safe disposal in a geologic media. Additionally, the program includes the identification and elimination of technical and institutional impediments to commercial reprocessing. Since additional spent fuel storage capacity will be required prior to the availability of commercial reprocessing services, the Agency, industry and utilities will participate in joint demonstration programs leading to the licensing of alternative storage techniques to enhance existing capabilities. The Budget Request for this program is $59.3 million, as compared to $52.7 million in FY 1982. The subprogram elements include: Reprocessing Technology, Waste Treatment and Storage Technology, and Spent Fuel Technology.

- Reprocessing Technology

  The fuel reprocessing research and development program provides for technology development in commercial fuel reprocessing and recycle. Process improvements for light water reactor fuel reprocessing are being addressed as are the more stringent requirements associated with reprocessing fast breeder fuels. The technical program is focusing on the development and demonstration of reprocessing technology that will provide for reduced occupational exposure, improved environmental protection, enhanced operational safety and reliability, acceptable economics, and improved safeguards.

In FY 1982, equipment will be installed and integrated into systems in the Remote Operations and Maintenance Demonstration (ROMD) section of the Integrated Equipment Test (IET) facility and tested for remote maintenance performance.

In FY 1983, the Integrated Process Demonstration (IPD) section of IET will be put into service. In addition, the IET will be completed for large-scale development and non-radioactive testing of reprocessing equipment and services. The modular shear will be completed and installed in ROMD as will the automatic in-cell samplers. Engineering development of remote maintenance equipment will continue. Efforts will also proceed on safeguards, spent fuel, plutonium and waste handling development at the Barnwell facility in South Carolina. Design studies of an advanced head-end facility colocated with an existing LWR reprocessing facility will continue.

o Waste Treatment and Storage Technology

The program is directed toward the safe handling, treatment, and interim storage of fuel cycle wastes prior to their permanent disposal. A significant activity is the selection of a commercial waste form and process that the Federal

Government would accept from a reprocessing operation. The Agency will continue work on transuranic waste management. Because management of transuranic and high level waste has similar needs and objectives, there will be close interaction and mutual support between the programs. Emphasis will be placed on the development of automated and remote operations for the higher radiation levels associated with commercial transuranic waste. The Agency will also initiate the conceptual design of a facility to provide interim storage of waste from reprocessing operations.

o Spent Fuel Technology

Analyses indicate that utilities will require interim spent fuel storage capacity in addition to their present pool-type storage. While the Agency believes that this interim storage is the responsibility of the private sector, we also see the feasibility of Government assistance and support in the commercial application of alternative storage technologies. Our experience has indicated the interim storage needs of commercial reactors can best be met by technologies such as rod consolidation and dry storage in casks. Thus, we are working with utilities with near-term storage problems to explore methods of applying these technologies to their particular needs.

The Agency's role in these cooperative efforts is to support utility license applications for rod consolidation and dry cask storage. Accordingly, we will develop generic licensing information that can be used by all utilities; provide removable or reusable equipment, such as a temporary storage cask or fuel disassembly equipment, for use in licensed storage operations; and conduct unlicensed storage demonstrations at a Government site with utility supplied fuel and casks in support of Nuclear Regulatory Commission requirements.

The utilities are expected to provide the reactor site and spent fuel used in the licensed storage operations. In addition, the utilities and private industry would provide the site specific equipment, personnel, and licensing documentation required and also any transportation services that are required.

The Agency will begin licensed use of boiling water reactor (BWR) fuel disassembly and rod consolidation during FY 1983 through a cooperative agreement with the Tennessee Valley Authority. Licensed use of a storage-only cask, procured by the Agency in FY 1982, is planned to begin in FY 1983.

Except for data on storage of consolidated rods in casks, we feel that a sufficient data base exists today to pursue licensing of rod consolidation and dry storage technologies. We have issued a report in FY 1982 on the technological status, licensability, and economics of dry storage.

THE REMEDIAL ACTION PROGRAM

The Remedial Action Program includes four subprograms for the elimination of residual radioactivity resulting from past nuclear operations at certain government-owned sites or at designated non-government sites. The Budget Request for the program in FY 1983 is $50.3 million as compared to $43.4 million in FY 1982.

Formerly Utilized Sites Remedial Action Program (FUSRAP)

The FUSRAP Program covers radioactively contaminated sites that were formerly owned, controlled, or used by the Manhattan Engineer District and the Atomic Energy Commission. Sites included for remedial action under this program have been determined to be insufficiently decontaminated to meet current guidelines for unrestricted occupancy or use. At present, 21 sites have been identified as needing remedial action and another 14 sites as probably needing remedial action. DOE has authority for remedial action at 13 of these sites.

In FY 1982, the cleanup of 27 contaminated properties in the vicinity of the former Middlesex Sampling Plant site at Middlesex, New Jersey was completed and the waste was stored on the Agency-owned site. The final phase of this project is to clean up the site and dispose of all the wastes. Several disposal options are being studied including use of other Federal sites. establishing a new State-owned site, possibly in conjunction with a State or regional low level waste site, or disposal under EPA permit at an Atlantic ocean site. A decision on the disposal option is planned for FY 1983. During FY 1982, cleanup of a privately owned parcel of land adjacent to the Niagara Falls Storage Site (NFSS) at Lewiston, New York was completed and the waste was stored on the DOE-owned site. Planning and engineering for cleanup of several miles of contaminated ditches leading from the NFSS is underway and ditch cleanup will be started in FY 1982 and completed in FY 1983. A contaminated landfill at Norton, Massachusetts was fenced, preparatory to other remedial action that is being planned for FY 1983. Engineering and environmental studies will be completed in FY 1982 for the Bayo Canyon and Acid Pueblo sites at Los Alamos, New Mexico. Remedial action on these sites is to be completed in FY 1983. We have been trying to proceed with a research and development project to stabilize wastes at the St. Louis Airport Site in Missouri, but have been unable to reconcile the issue of long-term responsibility for the site with the city. Cleanup of an off-site area that is the Agency's responsibility will be initiated as soon as the issue of a disposal site is resolved. Preliminary engineering and environmental studies for remedial actions at the Middlesex, New Jersey municipal landfill and the Linde Air Products site at Tonawanda, New York will be completed in FY 1982. Preparations for disposal of the Middlesex wastes will be completed in FY 1983.

Grand Junction Program

Under Public Law 92-314, Congress provided financial assistance to the State of Colorado to limit radiation exposure resulting from the use of uranium mill tailings for construction purposes at Grand Junction.

This Federal/State cooperative effort is conducted under contract to the Colorado Department of Health. The remedial action provides for removal of uranium mill tailings from the premises of about 740 structures where external gamma radiation or indoor radon daughter exposures exceed the Surgeon General's 1979 guidelines. Federal funds cover 75 percent of the program costs, with the State providing the balance.

The program had completed cleanup of approximately 430 of the sites by the end of FY 1981. In FY 1982 remedial actions will be completed for about 40 properties. In FY 1983 about 80 properties will be completed. The cleanup of remaining sites under the program is tentatively scheduled to be completed by 1985 and finally certified by 1987, but the pace of the program is currently dependent on the State of Colorado's providing its share of the funding.

Uranium Mill Tailings Remedial Action Program (UMTRAP)

In November 1978, Congress enacted Public Law 95-604, the Uranium Mill Tailings Radiation Control Act of 1978, which provides for the cleanup and stabilization of uranium mill tailings at 24 non-Federally owned inactive uranium processing sites, which were used for the production of uranium for sale to the Federal Government, and at any nearby properties contaminated with material derived from the sites.

The program will be conducted under cooperative agreements between the Federal Government and the affected States or Indian tribes. Remedial action costs will be shared on a 90/10 basis with the affected States. The Federal Government will pay all of the costs in the case of the Indian tribes.

The current project schedule for work on each of the 24 processing sites is based on the promulgation of final Environmental Protection Agency (EPA) standards for this program, currently anticipated in March 1982. The schedule calls for completion of the program within 7 years following the promulgation of the EPA standards, as authorized by P.L. 95-604.

Nine sites have been given a high priority on the basis of their potential for radiological hazards to the public. They are: Canonsburg, Pennsylvania; Salt Lake City, Utah; Durango, Colorado; the Shiprock, New Mexico site at the Navajo Indian Reservation, two sites at Rifle, Colorado; Gunnison, Colorado; Grand Junction, Colorado; and Riverton, Wyoming. Remedial action on the first processing site is to begin in the first quarter of FY 1984.

Cooperative agreements have been executed with Pennsylvania, Utah, and Colorado. The agreement with Colorado embraces all nine of the sites within that State. A proposed cooperative agreement with which to open negotiations with the Navajo tribe has been drafted and is under review within the Agency.

In response to DOE's presentation of a model draft cooperative agreement to the State of Wyoming, Governor Herschler has expressed deep concerns relative to parts of the proposed agreement. We are arranging to discuss Wyoming's problems with the draft agreement with representatives of the State's Office of the Attorney General.

Cleanup of a seriously contaminated vicinity property, Salt Lake City Fire Station #1, was completed in December 1981 using the interim EPA standards issued for this purpose in April 1980. Plans are in place for starting work on a second group of vicinity properties in Salt Lake City, and on an initial group of properties in Canonsburg, Pennsylvania, in the spring of 1982, pending the issuance of standards by the EPA.

Accomplishments planned for the budget request of $23.2 million in FY 1983 include completion of NEPA documentation (EIS's or EA's) for 11 sites, completion of remedial action plans and some detailed engineering for the first four high priority sites, the continuation of remedial action at vicinity properties at

Canonsburg and Salt Lake City, and start of vicinity property work at Durango and Rifle, Colorado.

Surplus Facilities Management Program (SFMP)

The Agency owns approximately 500 surplus facilities that are radioactively contaminated. About 100 of these are from activities related to development of commercial nuclear energy and are the responsibility of the Assistant Secretary for Nuclear Energy. The other 400 facilities are from defense activities and are the responsibility of the Assistant Secretary for Defense Programs. The facilities include reactors, fuel processing plants, laboratory buildings, tanks, and disposal facilities at about 17 sites throughout the United States and Puerto Rico. The objective is to decontaminate these facilities in order to eliminate the potential for significant personnel exposure or spread of contamination and to permit other productive uses where possible.

In FY 1982, Remedial Actions will continue at the Mound facility in Miamisburg, Ohio. The Mound cleanup, a major project jointly supported by the Offices of Nuclear Energy and Defense Programs, extends through 1988. Decontamination and decommissioning (D&D) of the Sodium Reactor Experiment power demonstration reactors at Santa Susana, California, will be completed in FY 1982. Engineering and planning for D&D of four other facilities at this Agency-leased site will continue in FY 1983. Preliminary engineering and planning for the D&D of the Shippingport Atomic Power Station will be completed in FY 1982. A draft Environmental Impact Statement has been issued for comment and the final statement is to be issued by this spring. The operation of the Shippingport reactor is to be terminated at the end of FY 1982 and the turnover of the facility for D&D work is to occur about July 1984. Other D&D work to be accomplished in FY 1982 includes the Agency-funded plutonium fabrication facilities at the Westinghouse Advanced Reactor Development, and similar facilities at Argonne National Laboratory and the General Electric Advanced Fuel Laboratory in California. The D&D of the reactor facility at the Center for Energy and Environmental Research at Mayaquez, Puerto Rico, and two nuclear rocket test stands at the Nevada Test Site will be completed. Stabilization of the R-10 uranium residues at the Niagara Falls Storage Site will be initiated.

URANIUM ENRICHMENT

The goal of the Uranium Enrichment Program is to meet domestic and foreign utility and United States Government requirements for uranium enrichment services in the most economical, reliable, safe and environmentally acceptable manner possible.

The FY 1983 budget for the Uranium Enrichment Program is shown in Chart 1 by major program component. The FY 1983 request is $1,967,046,000 for authorization and appropriation offset by $2,032,700,000 in projected revenues. FY 1983 excess revenues of $65,654,000 are to be carried over and used to offset FY 1984 requirements.

The Uranium Enrichment Program consists of three subprograms: (1) Uranium Enrichment Activities; (2) Advanced Isotope Separation, and (3) Uranium Resource Assessment.

PROJECTION OF URANIUM ENRICHMENT REQUIREMENTS

The Office of Uranium Enrichment and Assessment periodically estimates the domestic and non-U.S. nuclear electric generating capacity that will be served by the United States uranium enrichment complex.

Our latest estimates made last summer projected online worldwide nuclear power capacity to be served by the United States to be 137 gigawatts in 1985, 182 gigawatts in 1990 and 226 gigawatts in 1995.

CHART 1

URANIUM ENRICHMENT PROGRAM

	Budget Authority (Dollars in Thousands) FY 1982	Budget Authority (Dollars in Thousands) FY 1983
Uranium Enrichment Activities		
Gaseous Diffusion		
Cascade Power	$ 802,000	$ 904,000
Other Operations and Support	228,892	315,250
Total Gaseous Diffusion	1,030,892	1,219,250
Gas Centrifuge		
GCEP	588,000	613,000
Other Operations and Support	87,216	94,500
Total Gas Centrifuge	675,216	707,500
Program Direction	3,019	3,100
Total Uranium Enrichment Activities	$ 1,709,127	$ 1,929,850
Advanced Isotope Separation	85,711	34,196
Uranium Resource Assessment	9,979	3,000
Subtotal	1,804,817	1,967,046
Revenues	-1,830,200	-2,032,700
Revenues to be carried over to FY 1984	0	65,654
Total, Uranium Enrichment Program	$ -25,383*	$ 0

*The net FY 1982 appropriation after revenues is $1 million. The number shown reflects comparability adjustments.

Domestic nuclear power capacity in these totals are 90 gigawatts in 1985, 122 gigawatts in 1990, and 140 gigawatts in 1995. The forecast is based on reactors currently operating or under construction. Our total forecast estimate is lower than projected in last year's testimony by 7 gigawatts in 1985, 9 gigawatts in 1990 and 6 gigawatts in 1995. The reduced estimate reflects additional delays and/or cancellations of nuclear power construction.

Separative work requirements for these gigawatt projections are determined from near-term contract information and standardized boiling water and pressurized water reactor models in the longer term. The requirements also reflect the leadtime required for processing enriched uranium from the time of withdrawal from the enrichment plants and insertion into the reactor. In addition, separative work is required to support Government programs such as the Naval Reactor program and other defense programs. These requirements are provided to us by the appropriate program offices.

LONG-TERM STRATEGY

A long-term enrichment production strategy is developed to meet these requirements after considering a wide range of supply options. The strategy is chosen after considering economics, operational risks, and the flexibilities that are available to respond to higher or lower demand levels. In the short term, the strategy is to lower the operating levels of the gaseous diffusion complex, requiring power purchases below existing contract levels, and reduce inventories of enriched uranium. Even though this will require the Agency to pay capacity charges to its power suppliers for power not purchased, it remains the most economical way to operate in the long term. In FY 1983, the complex will operate at the same power levels as in FY 1982. These levels represent an acceptable level of risk of equipment failures from prolonged operations below plant design levels.

The long-term strategy is to continue design and construction of the Gas Centrifuge Enrichment Plant (GCEP) at Portsmouth, Ohio. The GCEP will initially provide an additional 2.2 million separative work units (SWU) of capacity by 1989. Capacity will be added in increments as dictated by demand, with completion of the full GCEP (eight process buildings) currently projected for 1994. This is the same schedule as was presented in the FY 1982 budget. Also, the output of the gaseous diffusion plants will be reduced in the mid-1990's by replacing some of the gaseous diffusion production with the less costly GCEP production. An advanced isotope separation process may be available for production in the mid-1990's providing further cost reductions by replacing gaseous diffusion capacity.

UNITED STATES COMPETITIVE POSITION

The current uranium enrichment market is highly competitive with a limited number of near-term sales opportunities, all of which are outside of the United States. The United States position in the non-United States market has declined from a 100 percent share in 1974 to about a 35 percent share today. A number of our foreign customers have switched from the United States to EURODIF, URENCO and the Soviet Union, and some new business has gone to these suppliers. Today we face competition in the international market from suppliers with the following enrichment capacities:

Foreign Suppliers of Uranium Enrichment Services
and Their Enrichment Capacity

Supplier	Capacity (Millions of SWU/Year)
USSR	3 to 4 available for export now
URENCO	0.6 operating; 2.0 committed; 3.0 possible by 1990
EURODIF	10.8 capacity, production will be at a lower level
JAPAN	2.0 possible by 1990
BRAZIL	no current capacity; 0.2 possible by 1985
AUSTRALIA	1.0 possible by 1995 and 3.3 in the year 2000 timeframe

To date, the total value of sales lost by the United States to its competitors is nearly $1.5 billion. During FY 1981 alone, the United States lost three enrichment contracts worth about $800 million over the lifetime of the nuclear reactors involved. This continues to be of great concern to us and we must reverse this trend.

Price has become a very important sales consideration to enrichment customers and our competitors have met this need by offering price guarantees equal to or slightly less than the United States by pricing on an incremental basis. Our competitors' strategy has proven quite successful in weakening the United States greatest market advantage. Last year, the United States enjoyed a price advantage of $30 to $50 per SWU. Since then the United States price increased by $20, the competitors have reduced their price, and fluctuating exchange rates have further reduced our competitors' prices. Our competitors' strategy, which was the primary reason the United States lost the three contracts in FY 1981 noted previously, has placed them in a very strong position to capture new sales opportunities in Taiwan and Mexico worth more than $1.3 billion.

Our competitors' ability to offer contracts with price, quantity, and timing provisions tailored to meet individual customer preferences has also given them an edge. We are not able to offer contracts on this basis due to the nondiscriminatory requirements legislated in Section 161v of the Atomic Energy Act of 1954, as amended.

To meet this challenge, we have implemented an active marketing effort to effectively enhance the sales advantages of the United States uranium enrichment program. Specifically, the uranium enrichment program is taking steps to minimize the current and future selling price by reducing operating costs at the gaseous diffusion plants, constructing GCEP, and pursuing more advanced and economically attractive technologies.

These efforts are beginning to produce results. We have recently signed a letter of intent with Egypt for the sale of one new uranium enrichment contract (to cover a 1,000 megawatt nuclear reactor) and an increased sales commitment of an existing contract (from 660 megawatts to 960 megawatts). From this action, we expect to realize about $20 million in additional annual revenues starting in the early 1990's, with a lifetime sales value in excess of $500 million.

Improvement in the United States marketing posture is expected to improve the probability of obtaining new sales in Taiwan, Switzerland, Mexico, Egypt and Yugoslavia. These sales are estimated to be worth more than $70 million in annual revenues starting in the early 1990's.

By maintaining and expanding our sales base, the United States will continue to realize significant benefits in terms of domestic employment, balance of payments and contribution to nuclear policies abroad.

URANIUM ENRICHMENT ACTIVITIES

The budget for Uranium Enrichment Activities as shown in Chart 1 is described in two major program activities: (1) Gaseous Diffusion and (2) Gas Centrifuge.

GASEOUS DIFFUSION

The United States presently enriches uranium to the desired U-235 product assay levels in its gaseous diffusion plants located at Oak Ridge, Tennessee; Portsmouth, Ohio; and Paducah, Kentucky. In these plants, the United States enriches customer-provided natural uranium in the U-235 component for a fee which recovers the cost of providing the services.

As indicated on Chart 1, $1,219,250,000 is requested for operation of the gaseous diffusion complex. The three gaseous diffusion plants will operate at a power level of 2,660 megawatts in FY 1983 and produce about 9.8 million SWU. The FY 1983 operating level is consistent with long-term enrichment strategy and represents an acceptable risk of process equipment failures from prolonged operations below plant design levels.

The 2,660 megawatt power level is substantially below the 4,548 megawatts we are contractually committed to purchase under existing contracts with the three power suppliers. Consequently, we are contractually required to pay about $151,000,000 (Tennessee Valley Authority (TVA)--$129,000,000, and Ohio Valley Electric Company (OVEC)--$22,000,000) in capacity charge payments in FY 1983 for power under contract that will not be purchased. If the Agency purchased power at the contractually committed level of 4,548 megawatts, the power budget would be increased by $394,000,000 from $904,000,000 to $1,298,000,000.

We are continuing discussions with the power suppliers in an attempt to reduce the capacity charge payments for power not purchased. As in the past, the success of these negotiations depends on the ability of our power suppliers to transfer contract power not purchased by the Agency to other customers. Relief from OVEC for FY 1983 is heavily contingent upon the level of economic activity in the Midwest. Relief from TVA is unlikely at this time because of the surplus generating capacity within TVA's own system, as well as within neighboring systems.

The total FY 1983 cascade power budget, including $151,000,000 in capacity charges, is $904,000,000. This is an increase of $102,000,000 over the FY 1982 budget and represents increases in the cost of power purchased due to higher coal costs and increased capacity charges for power not purchased.

Funding requested for diffusion operations, process and long range technical support, supporting services, capital equipment and construction is $315,250,000. The major increases over the FY 1982 budget are for common use stores and miscellaneous revenue expenses that were previously budgeted in the Agency's administration appropriation, and for escalation of costs. On a comparable basis and assuming an 8 percent cost escalation, the FY 1983 budget request is actually less than the FY 1982 budget. This reduction is the result of a deliberate effort by the Office of Uranium Enrichment and Assessment to minimize costs. In turn, SWU price increases will also be minimized. The requested funds are the minimum amounts needed to operate the plants; to replace equipment that has exceeded its useful life; to properly maintain the plants; and to comply with environmental and safety standards.

GAS CENTRIFUGE

The FY 1983 budget request contains $613,000,000 for the construction of the Gas Centrifuge Enrichment Plant (GCEP) and $94,500,000 for other centrifuge activities.

The GCEP will provide an additional 2.2 million SWU per year of capacity by 1989. This GCEP capacity can be further increased to 3.3 million SWU per year through retrofit with advanced gas centrifuge machines now in development. Utilizing advanced centrifuge machines, GCEP will be completed by adding capacity in blocks of 1.65 million SWU sequentially as dictated by demand up to a total of 13.2 million SWU per year. Completion of the full GCEP is currently projected for 1994. This is the same schedule as was presented in the FY 1982 budget.

The construction of GCEP, authorized in FY 1976, provides the only legal basis for reopening the United States order books. In addition, GCEP represents the only additional technology which has demonstrated a production reliability sufficient to guarantee that the U.S. can, in fact, meet additional sales commitments from new contracts. This ability to contract with the foreign and domestic utilities is necessary to maintain a United States position as a major world supplier of uranium enrichment services.

Projections of the long-term United States uranium enrichment market share show that additional capacity is needed to meet demand in the 1990's. Strategic analyses indicate that GCEP should be used to meet this demand because GCEP provides the most economical, currently available means of supplying enrichment services. The GCEP is expected to produce separative work at a lower cost than gaseous diffusion production. This will lower the price of enrichment services which will lower the total cost of enriched uranium for customers. Lowered prices, in turn, will improve the United States competitive position in the international marketplace. The availability of GCEP also provides the opportunity to displace more costly gaseous diffusion production.

Our analysis also shows that the incremental cost of completing the full eight-process-building plant is cost competitive with the advanced isotope separation processes when an adjustment is made to reflect the uncertainties of the advanced processes. If successful, an advanced isotope separation process will provide an alternative for lower cost production in future plants and further displacement of the gaseous diffusion plants.

GCEP is making excellent progress and is on schedule with the total estimated cost (adjusted for escalation) holding constant. Project momentum continues to build as the physical construction at the site near Portsmouth, Ohio, progresses. Process Building No. 1 is enclosed, the floor modules for the centrifuge machines are installed, and contracts have been let for the process piping, electrical, heating and ventilation systems. Site preparation and rough grading for all eight process buildings is complete. The fire station, central receiving warehouse, mobile equipment garage, the administration building, and several supporting facilities are finished. Work is well underway on the Recycle/Assembly building, electrical substations, and the process support building. Through FY 1982, $1,585,520,000 has been authorized and $1,539,845,000 appropriated, with estimated costs of $1,197,531,000 against a total estimated project cost of $6,950,000,000 in FY 1983 dollars. Design of the entire complex is over 72 percent complete with six of the nine major architect engineers having essentially finished their design efforts. Three centrifuge machine manufacturers have constructed manufacturing facilities using corporate funding in Ohio and Tennessee. All of the centrifuge manufacturers are in production and have delivered centrifuge machines that have passed the 2,000-hour evaluation test. This demonstrates the capability of United States industry to manufacture the baseline centrifuge.

The FY 1983 request for other centrifuge operations and support on Chart 1 includes the funds to proceed with operational startup plans and procedures to support operation of the first production units of the GCEP, continuation of the advanced gas centrifuge development program, capital equipment and construction. The FY 1983 budget request for these activities is $94,500,000 or an increase of $7,284,000 over FY 1982. GCEP startup activities are increasing by $7,600,000 and developmental activities declining $316,000. Assuming 8 percent escalation, the centrifuge development activities are declining about $6,877,000. This decline reflects a maturing of the centrifuge program.

The Advanced Gas Centrifuge (AGC) program is designed to provide a production centrifuge with separative capacity 50 percent greater than the baseline centrifuge. The advanced technology is an extrapolation of the technology already developed and will be achieved through a modest increase in speed and improved flow management. Development of this design is currently underway and about one-half of the performance increase has already been achieved in early test centrifuges. The advanced technology objectives are reasonable and the probability of this technical achievement is high. We expect that the 50 percent increased performance machine will be available for installation in the third GCEP process building and can be retrofitted into process buildings 1 and 2.

ADVANCED ISOTOPE SEPARATION

The primary objective of the Advanced Isotope Separation (AIS) program is to develop a technology capable of producing enriched uranium at a cost of less than $40 per SWU in FY 1981 dollars. In addition to low overall cost, AIS offers a process with a low capital investment requirement and low energy consumption. Successful development and deployment of AIS may help replace power intensive diffusion plants or provide new enrichment capacity.

The budget request for the AIS program in FY 1983 is $34,196,000 in budget authority compared to $85,711,000 in FY 1982. Operation within this reduced budget is possible by selecting one of the three processes after all essential technical data have been compiled and evaluated for advancement to the engineering development and demonstration phase, and completely terminating in FY 1982 all activities associated with the two nonselected processes.

During the past year, excellent progress has been made on the plasma, atomic vapor, and molecular AIS processes. The primary emphasis in FY 1982 is on the operation of the preprototype testbed systems that are providing a major portion of the data needed for identifying the engineering uncertainties associated with scaling the AIS technologies. This information, along with offline component tests and economic analysis, provide input for both process selection and future engineering development.

In FY 1983 the Agency will upgrade and continue operation of the selected AIS preprototype system and initiate prototype engineering of components by subsystem integration efforts. This approach will provide initial development of the specifications required for the near-production-scale components for the Development/Demonstration Module.

URANIUM RESOURCES

Assessments of United States resources indicate that at least 1 million short tons of U_3O_8 could be recovered at a forward cost of $30 per pound U_3O_8 from reserves and probable potential resources; uranium recovered at a cost of $30 per pound U_3O_8 would be expected to require prices averaging about $45 per pound. Although the average delivery price for uranium was $31 per pound in 1981, and spot prices were about $25 per pound, uranium priced at $45 per pound should result in nuclear power plant operating costs that continue to be lower than the operating costs in coal-fired power plants in most areas of the United States.

The current forecast range of domestic nuclear power growth indicates that as much as 195 gigawatts could be operating by the year 2000. The 1 million short tons of U_3O_8 should be able to support these reactors into the next century.

STATE OF THE DOMESTIC URANIUM PRODUCING INDUSTRY

The United States uranium industry faces a difficult situation. The industry has overbuilt production capacity and must reduce production in order to be in better balance with demand. The adjustments must be made primarily because of the reductions in uranium demand and falling prices resulting from nuclear power reactor construction delays, cancellations, and lack of new reactor orders. This situation has caused some producers extreme economic hardship and will cause continued economic difficulties over the next few years. On the other hand, some producers reported a profitable year in 1981. After the adjustments are completed, the companies that remain as domestic uranium producers should comprise a viable industry. Other producers can enter the industry as the uranium demand grows.

In 1980, the United States uranium industry produced a record 21,850 short tons of U_3O_8. In 1981, the industry produced about 19,000 tons, and in 1982, we estimate a production of about 15,500 tons. Most of this production will be used directly to supply reactor needs, although some of the uranium is projected to be added to utility inventories. In the mid-1980's, domestic utilities are projected to have an average annual requirement (which includes purchase commitments plus uncontracted needs) of about 15,500 tons. Thus, requirements should be in approximate balance with current production. As reactors now under construction begin operation, we expect the domestic utilities' annual requirement for uranium to increase to about 20,000 tons in 1990 and to about 30,000 tons in 1995.

The reduction from the record production level of 21,850 tons to today's production resulted from some mines and mills closing or curtailing production. Employment in the uranium industry has dropped from an all time high of 22,000 in 1979 to around 15,000 at the end of 1981.

Surface drilling for uranium exploration and ore deposit development reached an all time record of 47 million feet drilled in 1978, but has dropped to an estimated 14 million feet in 1981. The outlook for industry exploration work is uncertain at present.

Restrictions on the enrichment of foreign uranium for domestic end-use are being removed in steps according to a plan announced in 1974 by the Atomic Energy Commission in accordance with Section 161v of the Atomic Energy Act of 1954, as amended. The plan allowed initial use of foreign uranium in 1977 limited to 10 percent of an enrichment services customer's feed deliveries to the Agency. The allowable percentages increased to 15 percent in 1978, 20 percent in 1979, 30 percent in 1980, 40 percent in 1981, and 60 percent in 1982. The plan increases the percentage to 80 percent in 1983 and in 1984 there would be no established limit.

In the 5 years from 1977 to 1981, domestic use of foreign uranium has been low as United States buyers have preferred to buy United States uranium. Over the 5 years, only 8 percent of the uranium delivered for enrichment by domestic customers was of foreign origin, compared with an allowable weighted average of 22 percent. In 1981, the actual deliveries of foreign-origin uranium for enrichment have been 9 percent of total domestic deliveries, well below the allowable 40 percent. Although there will be continued and probably increasing use of foreign uranium in the United States, we expect United States buyer preference for domestic uranium to continue.

URANIUM RESOURCE ASSESSMENT PROGRAM

Because the priority work of the assessment program has been completed, and because of the projected adequacy of the uranium resources to support the industry's needs into the next century, the program is being phased out in FY 1982 and will be terminated in FY 1983.

The goals of the assessment program were to assess and expand the nuclear fuel resource base of the United States; reduce uncertainties about the extent, availability and economics of domestic and foreign nuclear fuel resources; and make available to industry resource information and technology for use in the discovery and production of uranium resources. The program has estimated uranium reserves based on proprietary industry data, analyzed uranium supply, assessed potential uranium resources, developed improved methodology and technology for resource identification, and assessed and supported international activities to estimate the world uranium resource base.

During FY 1982, steps will be taken to complete projects underway and to put the very large data base in order for possible future use. Reduction in force and the termination of the operating contractor at Grand Junction will have to begin in FY 1982 in order to meet required notification periods and funding constraints. Funds requested for FY 1983 are to complete the program closeout activities.

Mr. Chairman, this completes our discussion of the objectives, strategies, and status of the subject programs.

OFFICE OF THE ASSISTANT SECRETARY FOR NUCLEAR ENERGY

NUCLEAR ENERGY PROGRAM

- Conventional Reactor Systems
  - LWR
  - TMI
  - HTGR
  - ARS (RERTR)

- Breeder Reactor Systems
  - LMFBR
  - CRBR
  - WCB
  - Fuel Cycle

- Advanced Nuclear Systems
  - Space and Terrestrial

- Commercial Nuclear Waste
  - Commercial Waste Management
  - Spent Nuclear Fuel

- Remedial Actions

- Uranium Resource Assessment

Energy Production and Power Marketing

- Uranium Enrichment Activities
  - Diffusion Program
  - GCEP
  - Revenues
  - AIST

Defense Activities

- Naval Reactors
  - Plant Development
  - Reactor Development
  - Reactor Operation and Evaluation

OFFICE OF THE ASSISTANT SECRETARY FOR NUCLEAR ENERGY

(FY-1981, 82, 83)
BUDGET SUMMARY
(BA in Millions)

	FY 1981 APPROP.	FY 1982 APPROP.	FY 1983 REQUEST
ENERGY SUPPLY R&D	1,051	1,089	1,017
CONVERTER	83	96	32
BREEDER	611	647	577
ADVANCED NUCLEAR SYSTEMS	40	38	31
COMMERCIAL NUCLEAR WASTE	189	210	81
NUCLEAR WASTE DISPOSAL FUND	--	--	185
REMEDIAL ACTIONS	43	43	50
NUCLEAR FUEL CYCLE	83	53	59
POLICY AND MANAGEMENT	2	2	2
URANIUM ENRICHMENT	-23	-25	0
ENRICHMENT	1,167	1,709	1,930
ADVANCED ISOTOPE SEPARATION TECHNOLOGY	80	86	34
URANIUM RESOURCE ASSESSMENT	31	10	3
REVENUES	-1,301	-1,830	-2,033
DOE RESERVE FOR FY 1984	--	--	66
ATOMIC ENERGY AND DEFENSE	303	359	376
NAVAL REACTORS DEVELOPMENT	303	359	376
TOTAL - NUCLEAR ENERGY	1,331	1,423	1,393

PRESIDENT'S NUCLEAR POLICY

Energy Supply R&D

- Revitalize LWR Industry
- Waste Disposal
- Breeder Reactors
- Commercial Reprocessing

ASSISTANT SECRETARY FOR NUCLEAR ENERGY

FY 1983 BUDGET REQUEST

(Dollars in Billions)

OF THE $3.4 BILLION PROGRAM MANAGED BY THE ASSISTANT SECRETARY FOR NUCLEAR ENERGY, $1.0 BILLION IS INCLUDED IN THE ENERGY SUPPLY R&D APPROPRIATION.

TOTAL	$3.4
LESS DEFENSE ACTIVITIES (NAVAL REACTORS)	- .4
LESS PRODUCTION OPERATIONS (URANIUM ENRICHMENT)	-2.0
ENERGY SUPPLY R&D (NUCLEAR FISSION)	$1.0

ASSISTANT SECRETARY FOR NUCLEAR ENERGY

FY 1983 BUDGET

(Dollars in Millions)

OF THE $1 BILLION ENERGY SUPPLY R&D APPROPRIATION, $670 MILLION IS FOR PROGRAMS WITH COMMERCIALIZATION POTENTIAL.

TOTAL	$1016
LESS NONCOMMERCIAL PROGRAMS	
o WASTE MANAGEMENT	- 265
o REMEDIAL ACTIONS	- 50
o ADVANCED NUCLEAR SYSTEMS (SPACE)	31
FISSION PROGRAMS WITH COMMERCIALIZATION POTENTIAL	$ 670

ASSISTANT SECRETARY FOR NUCLEAR ENERGY

FY 1983 BUDGET

PROGRAMS WITH COMMERCIALIZATION POTENTIAL

	FY 1982	FY 1983
BREEDER REACTORS	647	578
(CRBR)	(194)	(253)
CONVERTER REACTORS	96	32
FUEL CYCLE	53	60
TOTAL	796	670

TOTAL PROGRAM REDUCTION= 16 PERCENT

REDUCTION OF PROGRAMS OTHER THAN CRBR = 31 PERCENT

ASSISTANT SECRETARY FOR NUCLEAR ENERGY

FY 1983 BUDGET

SPECIFIC PROGRAM REDUCTIONS

	FY 1982	FY 1983	△
BREEDER BASE R&D	367	261	-106
CONVERTER REACTORS	96	32	- 64
WATER COOLED BREEDER	52	42	-10
ADVANCED REACTOR SYSTEMS	4	0	- 4

ASSISTANT SECRETARY FOR NUCLEAR ENERGY
FY 1983 BUDGET
SUMMARY

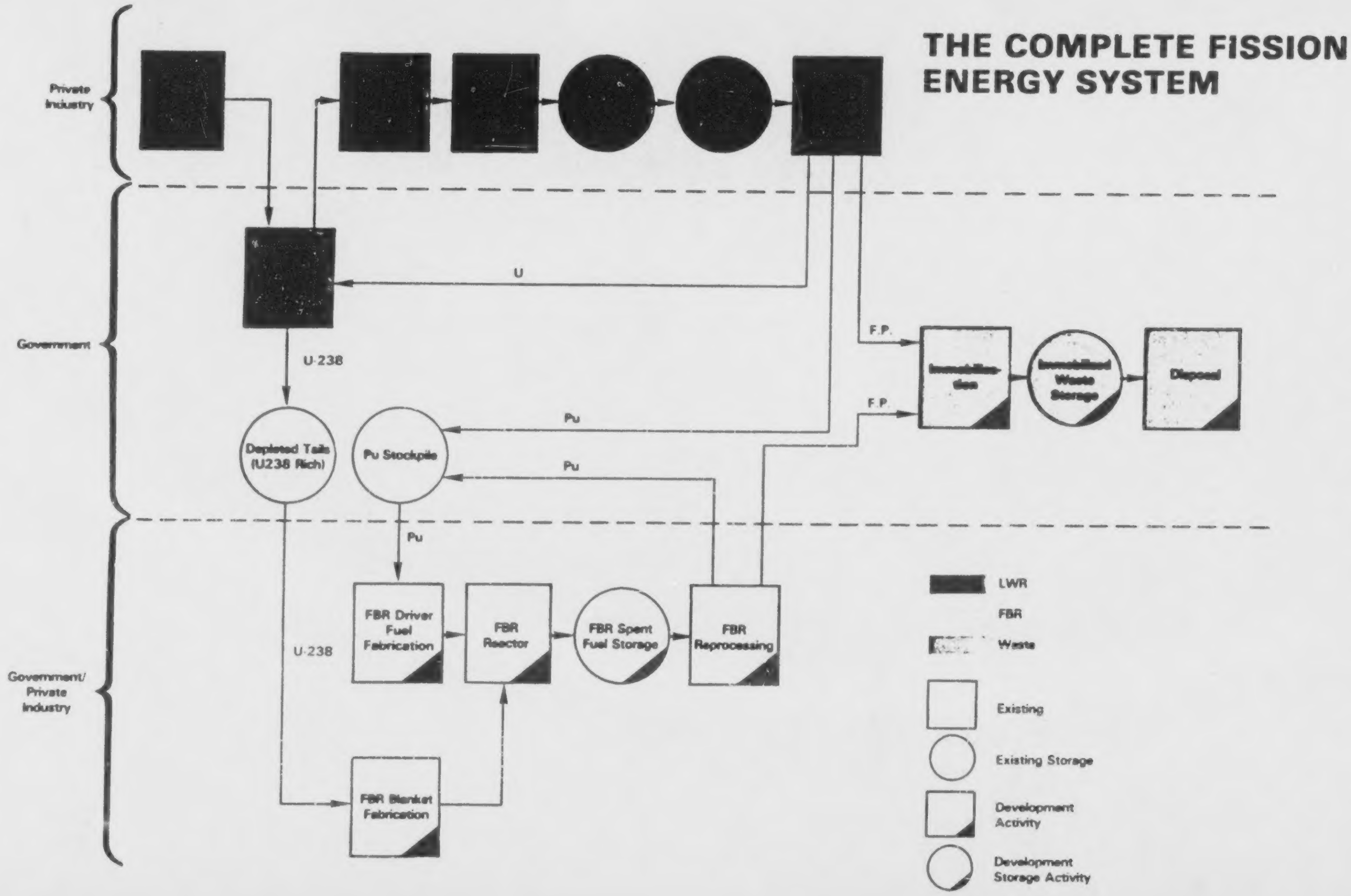
FY 1983 REQUEST FOR FISSION PROGRAMS WITH COMMERCIALIZATION POTENTIAL UNDER ENERGY R&D

- REPRESENTS LEGITIMATE LONG TERM, HIGH RISK, HIGH POTENTIAL BENEFIT R&D
- IS FOCUSED ON SEVERAL CLEARLY DEFINED MAJOR MISSIONS
- IS REDUCED COMPARED TO FY 1982
- IS RESPONSIVE TO PRESIDENT'S NUCLEAR POLICY DIRECTIVE

ENERGY SUPPLY R&D
(BA IN $ MILLIONS)

	FY 1982	FY 1983
Breeder Systems	647	577
Converter Systems	96	32
Advanced Nuclear Systems	38	31
Remedial Actions	43	50
Nuclear Fuel Cycle	53	59
Commercial Nuclear Waste	210	81
Policy and Management	2	2
Subtotal	1,089	832
Nuclear Waste Disposal Fund	0	185
Total	1,089	1,017

THE COMPLETE FISSION ENERGY SYSTEM


Private Industry
Government
Government/ Private Industry
U
U-238
F.P.
F.P.
Immobiliza-tion
Immobilized Waste Storage
Disposal
Pu
Pu
Depleted Tails (U238 Rich)
Pu Stockpile
Pu
FBR Driver Fuel Fabrication
FBR Reactor
FBR Spent Fuel Storage
FBR Reprocessing
U-238
FBR Blanket Fabrication
LWR
FBR
Waste
Existing
Existing Storage
Development Activity
Development Storage Activity

Senator **Domenici**. Let me try a couple of questions. Let's talk a little bit about one of the items you referred to. I think it is somewhat significant if we have a Presidential policy to revitalize light water reactors program from the standpoint of use in the country that we talk a little bit about domestic uranium.

You recall that you testified before us last year on the state or health and viability, of the domestic uranium industry. You had completed a mandated study as I recall. At that time you presented that report which concluded that no policy actions were proposed to the industry. I think I alluded at that point, Mr. Secretary, to the fact that we apparently had just concluded the study—not your fault, but the way we ordered it. It was concluded just before a series of closures in the industry, a series of withdrawals of investments by a number of companies.

Now, you recommended then that the best course was to continue to monitor the industry and the level of imports.

In reviewing this budget I note that uranium resource assessment is being terminated. All the activities for monitoring the status of domestic industry and conduct of the foreign industry, at least as I understand it, will be shut down if that occurs.

Now, is that what you really recommend occur in light of the evidence that is around as to the tremendous changes that are occurring which seems to me to require some updating. I also understand that the Grand Junction office is being shut down, if that's what I read into the budget. I would just like some specifics on that as to when we might have an opportunity to look at that.

Would you tell me, am I correct in my assessment? If I am, how are you going to live up to the commitment which you made that you are going to keep monitoring the situation? How can you monitor the imports and the status of the industry if you don't have any program?

Mr. **Brewer**. Mr. Chairman, I think there is no doubt that the uranium industry is severely depressed. We have a statutory requirement to measure and assess the viability of the industry. That function in the Department which is mandated, I believe, by the Atomic Energy Act of 1954 has been transferred to the Energy Information Agency. Mr. Voigt, do you have more specifics on that matter?

Mr. **Voigt**. I think you raised the question is this what the Department requested of OMB on the original budget submission. The original Departmental request to OMB was for $10.8 million which would have carried the program through fiscal year 1983.

However, the budget now includes only $3 million which is for the closeout and termination cost associated with the Grand Junction office as well as the contractors.

Senator **Domenici**. I believe the Secretary asked you if you know to tell us whether the Energy Information Agency would do some of this work because they are mandated by some generic law to do it. Do you know the answer?

Mr. **Voigt**. The EIA has been chartered with the responsibility for conducting the market surveys which have heretofore been under the responsibilities of nuclear energy.

It is unclear to me at this particular point, Mr. Chairman, as to who would be policing that section of the act relating to the viability of the industry.

Senator DOMENICI. Do you understand that OMB recommended this phaseout shutdown because they stated it was going to be done somewhere else, or isn't this one they think we should do?

Mr. VOIGT. It was somewhat implicit, Mr. Chairman, in their zeroing out of the program that this responsibility would be picked up by some other agency.

Senator DOMENICI. With all due respect to OMB, they do that frequently, but then they cut the other agency that's suppose to do it too.

Can you get us an answer as to who is expected to do it and what kind of resources are there?

Mr. BREWER. Yes, sir. I will check.

[The following was submitted to the subcommittee:]

The OMB was contacted regarding the subcommittee's questions about the disposition of the uranium resource assessment program responsibilities, and the availability of resources in other agencies. The requested information will be provided to the subcommittee in the near future.

Senator DOMENICI. I am personally going to resist it. Have you had enough time before you are phased out to tell us whether that assessment of the industry's viability has changed dramatically from that past study?

Mr. VOIGT. No, sir. We don't have any recent information which would alter the conclusions reached in the report that was forwarded to you.

Senator DOMENICI. That is not to say there isn't recent information. You say you don't have it?

Mr. VOIGT. That is right.

Senator DOMENICI. Can you get it in the next couple of months?

Mr. VOIGT. We will perform an update of the study that we performed in the past for the subcommittee and forward the results as soon as possible.

Senator DOMENICI. I think if you would do that for us it would be appreciated. I don't think it would be very difficult. I think it would show a dramatic change has occurred.

Mr. VOIGT. There are several mines that have been closed since then.

Senator DOMENICI. And not only in my State. Some prospective future capacity was terminated by some major companies. If you could get that study current and submit it as an answer to the question, it would be helpful to us.

I think you are aware, Secretary Brewer, that there is considerable concern in the Senate that the Nuclear Regulatory Commission has proceeded to promulgate regulations for the cleanup of active sites, and they did that in the absence of any Environmental Protection Agency health and safety standards.

You are aware of that scenario that they did that, are you not?

Mr. BREWER. Yes, sir.

Senator DOMENICI. Now, there is an amendment that we have pending that would correct this. I'm wondering if you could tell me whether you've looked at that amendment and whether you believe it will reflect your program of remedial action?

Mr. **Brewer**. Mr. Chairman, our start onsite will be triggered by the EPA standards. That is why we are waiting, and we have been negotiating intensively with EPA on the nature of those mill tailing standards.

Senator **Domenici**. So, unless that amendment could be, in some way, construed to delay EPA, it could have no effect?

Mr. **Brewer**. That's correct.

Senator **Domenici**. I construe it to accelerate what has heretofore been inaction by setting a firm date and telling them to do it. I have no reason to suspect to the contrary.

The reason I ask is that there is great confusion between the active and your remedial which is inactive. Some construe that since I'm saying hold up until we get the EPA that I'm holding up your remedial program, and you are telling us we are not?

Mr. **Brewer**. That's not a problem, Mr. Chairman.

Senator **Domenici**. The staff has looked at your testimony. I have not had an opportunity, but I note your efforts to coordinate the costs with NASA and the Department of Defense in the space reactor technology program, and I commend you for those efforts. In talking with my staff about this I have concluded that I think it is rather ridiculous that you have to continue to negotiate this issue. I think it should have been done a long time ago. I'd be prepared to suggest that if the negotiations aren't finalized soon that the Department curtail its activities in this area.

Now, you may not have that much liberty to speak, but I would ask you if you had any comments.

Mr. **Brewer**. We are still negotiating. We are planning, in fact, an increase in the space reactor area in fiscal year 1983.

We are anticipating a new mission statement from the Department of Defense and NASA, but we are still negotiating the dollars.

Senator **Domenici**. And you want to continue that?

Mr. **Brewer**. I would like to get the matter settled.

Senator **Domenici**. You aren't the one that is dragging your feet, are you?

Mr. **Brewer**. No.

Mr. **Chipman**. Mr. Chairman, on that matter, in the Budget Reconciliation Act of last year the House conference report which became part of the conference report for the whole bill, stipulated that NASA, at the beginning of 1983, should provide full reimbursement for not only the RTG units as they currently do, but in addition, the qualification and spare units. It is on that basis that we are now discussing this issue with NASA.

Unfortunately, both agencies do have severe budget problems, as you know. It is within the framework of that direction from the House to resolve this issue.

Senator **Domenici**. It isn't any easier for you all to get money than it is for them. It seems at least the legislative attempt is rather clear. That is the basis of the negotiation is the clear attempt expressed in the statement of the manager's language on reconciliation.

Mr. **Chipman**. Yes, sir.

Senator DOMENICI. It is my understanding, Mr. Secretary, that we are getting very close to a critical decision in the advanced isotope separation program; is that right? We are getting very close?

Mr. BREWER. Yes, sir. We have a decision scheduled for this spring.

Senator DOMENICI. Could I express some concerns? I hope that you will be able to dispell them. I am concerned that this decision which is going to spell out the future path of uranium enrichment program could be done in less than a businesslike fashion. Obviously it has to be run in a businesslike fashion, or we have real problems.

Let me ask you three questions. Could you tell the committee the criteria that are being evaluated among the competing programs for this upcoming decision?

Mr. BREWER. Mr. Chairman, evaluating criteria include the scaleup risk, economics and other criteria. Mr. Voigt, would you like to comment?

Mr. VOIGT. A very detailed set of selection criteria was developed in concert with each of the three participants in the isotope separation program.

I can answer your question best by suppyling for the record that selection criteria.

Senator DOMENICI. Will you do that for us?

Mr. VOIGT. I would be happy to.

[The information follows:]

ADVANCED ISOTOPE SEPARATION PROGRAM

SELECTION
CRITERIA

AUGUST 13, 1981

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1.0 Purpose and Summary

The purpose of this document is to set forth the selection criteria and grading system to be used in selecting one of the Advanced Isotope Separation (AIS) processes for engineering development by mid FY82. Selection will be based on in-depth reviews and evaluations of each of the three contending processes and the prime contractors listed below:

Atomic Vapor Laser Isotope Separation (AVLIS) being pursued by Lawrence Livermore National Laboratory (LLNL),

Molecular Laser Isotope Separation (MLIS) being pursued by Los Alamos National Laboratory (LANL),

Plasma Separation Process (PSP) being pursued by TRW, Inc.

The selection process will primarily involve interactions among the participating process developers, and a Process Evaluation Board (PEB).

The function of the PEB is to recommend to the Under Secretary, the DOE selecting official, which process should proceed toward full scale engineering development.

1.1 AIS Purpose and Objectives

1.1.1 AIS Goals and Benefits

The goal of the DOE uranium enrichment program is to meet domestic, foreign, and U.S. Government requirements for uranium enrichment services in the most economical, reliable, safe and environmentally acceptable manner possible. The process which best meets the above objectives will be selected.

The goal of the AIS program for the last several years has been to develop a uranium enrichment technology which will produce enriched uranium at a cost less than $40/SWU (computed at 10 percent interest and 10 year write off). Recent changes in economic assumption of extending the write off time from 10 years to 25 years has the affect of lowering the $40/SWU to about $30/SWU. Benefits of the lower enrichment cost support the following missions:

- o Replace power intensive diffusion plants
- o Economically lower the tails assay of the enrichment enterprise
- o Supply additional separative work capacity as required for expansion of nuclear power.

The relative value of these missions measured in terms of the anticipated present value benefit is presented in Table 1.1 for a medium nuclear power deployment projection.

Table 1.1

AIS Present Value* Benefits for a $30/SWU Process

(Through the Year 2024)

(FY 1980 Dollars** in Billions)

MISSION	
Replace Diffusion Plants	2.7
Lower Tails Assay	2.0
New Capacity	0
Total	4.7

*Discount Rate = 10%/yr
**LEVEL OF NUCLEAR POWER SUPPORTED BY THE U.S. ENRICHMENT ENTERPRISE IN THE YEAR 2000 IS (250 GWe)

1.1.2 AIS Program Objectives

The next significant engineering scale up is the development module (DM). The DM and other offline development in the late 1980's have the following goals and objectives:

- First fully integrated process demonstration
- Mechanism for technology transfer
- Development of firm data base to project plant economics
- Readiness of process to proceed to production with low to moderate technical risk

Program plans submitted for consideration in the selection process should outline the tasks and estimate the costs of the engineering development and demonstration of the required technology to the start-up of a nominal 9 million SWU/yr plant in the early to mid 1990's.

1.2 Selection Schedule and Information Flow Sequence

The schedule for making the selection is presented in Table 1.2. The process will culminate in early April 1982 when the PEB and Assistant

Secretary of Nuclear Energy recommend to the Under Secretary which process to select for engineering development. The PEB will be active in the selection process although no schedule of their activities is presented. It is expected that the PEB will:

- Visit all sites and facilities.
- Obtain independent evaluations of data and designs as required.
- Rank the three contending AIS processes based on the selection criteria.

Table 1.2

SELECTION INFORMATION FLOW SEQUENCE

Action Item or Transmittal	From	To	Date
1. Revised Baseline/Alternates Description	Labs	UCC-ND/PEB	09/01/81
2. Final Conceptual Design Report on Development Module	Labs/UCC-ND	DOE	09/15/81
3. Projections of Preprototype Performance	Labs	PEB	09/30/81
4. Document Preprototype Capabilities Relative to Scaling and Future Systems	Labs	PEB	11/01/81
5. Documentation of Science and Technology Base	Labs/UCC-ND	PEB	12/01/81
6. Economic Assessment Draft	UCC-ND	Labs/PEB	12/10/81
7. Complete Peer Review Documents	Labs/UCC-ND	PEB	12/15/81
8. Complete Program Plan, Costs, and Schedule	Labs/UCC-ND	PEB	01/07/82
9. Recommended Changes in Baseline Plant Design (Limited to changes where process model and cost equations remain valid)	Labs	UCC-ND/PEB	01/08/82
10 Preconceptual Design Report for Large Plant Study	Labs/UCC-ND	PEB	01/10/82
11. Proliferation Assessment		PEB	01/31/82
12. Safeguards Assessment (Draft)	BNL	PEB/Labs/UCC-ND	01/31/82
13. Updated Science, Technology and Preprototype Information	Labs/UCC-ND	PEB	02/01/82
14. Final Economic Assessment	UCC-ND	PEB/Labs	02/12/82
15. NEPA Environmental Assessment (Draft)	PNL	PEB/Labs/UCC-ND	02/15/82
16. Final Documentation of Preprotype Performance	Labs	PEB	03/01/82
17. Final Presentations to PEB	Labs/UCC-ND	PEB	03/16 - 19/82
18. PEB Recommendation	PEB	AS/US	04/02/82

Table 1.2 (continued)

SELECTION INFORMATION FLOW SEQUENCE

US - Under Secretary
UCC-ND - Union Carbide Corporation-Nuclear Division
LANL - Los Alamos National Laboratory
Labs LLNL - Lawrence Livermore National Lab
TRW
PNL - Pacific Northwest Laboratory

AS - Assistant Secretary
PEB - Process Evaluation Board
DOE - Advanced Isotope Separation Office
BNL - Brookhaven National Laboratory

1.3 Overview of Selection Criteria

A point system will be used to rank the processes with the evaluation broken down into several categories as illustrated in Table 1.3.

The objectives of the technical aspects of the evaluation of each process are to ascertain its current status, to project its potential, and to evaluate the risk associated with the projection to future potential. The great technical variety between the programs requires the development of a general methodology for evaluation which will allow for the application of identical rules to all aspects of each process. In order to measure the relative importance of the various aspects of each process, where practicable a measure of system or subsystem performance and costs must be related to their impact on some common measure of benefit such as $/SWU.

Selection criteria for environmental assessments, proliferation and safeguards will be used at the PEB's discretion. Based on previous assessments, it is not anticipated that these factors will be the decisive ones; however, they will be evaluated.

TABLE 1.3

EVALUATION CATEGORIES AND POINT ALLOCATIONS

CATEGORY	POINTS	TOTAL FOR SECTION
DESIGN EVALUATIONS		15
A. BASELINE PLANT DESIGN		
B. DEVELOPMENT MODULE DESIGN		
PROCESS PERFORMANCE AND RISK EVALUATIONS		60
A. SYSTEMS INTEGRATION, STATUS, AND SCALING		
1. PREPROTOTYPE PERFORMANCE		
2. INTEGRATED EXPERIMENTS		
B. SUBSYSTEM STATUS AND SCALING		
1. FEED SOURCE		
2. INTERACTION ZONE AND PROCESS CHAMBER		
3. ELECTROMAGNETIC SIGNALS		
4. EXTRACTOR/COLLECTOR		
5. INTERSTAGE EQUIPMENT		
C. SYSTEM INTEGRATION ANALYSIS		
ECONOMIC EVALUATION OF BASELINE PLANT		10
A. BENEFIT FROM SWU COST, DEVELOPMENT COST AND PROCESS DEPLOYMENT DATE		
TECHNOLOGY DEVELOPMENT AND PRODUCTION IMPLEMENTATION PLAN		15
	TOTAL POINTS	100

2.0 Design Evaluation

A prerequisite for engineering development of any process is the existence of well conceived and complete designs for both demonstration facilities and a full scale plant. The objectives of the design activities include establishing a consistent, comprehensive framework for cost estimates, schedules, operational evaluations, and various assessments, as well as providing a reference point for process/program requirements and the associated technical evaluations. Such designs also help the developer to focus on those issues most relevant to the economic feasibility of a given process. Keeping in mind the above guidelines it is the purpose of this section to provide a scoring system for evaluating the completness and depth of both the baseline plant and DM designs.

The evaluation of the designs to be accomplished in this section will serve as a measure of risk based on the completeness of the designs. The evaluation will give visibility to the scaling issues for each process and, since a considerable amount of engineering has been accomplished on these designs, will also be indicative of the level of technological sophistication required for each process.

2.1 Baseline Plant Design

Each process proponent in conjuction with UCC-ND is responsible for developing the design of a baseline isotope separation plant which employs his technology. The information presented in subsequent sections on Development Module Design, Preprototype Performance, Process Subsystem Status and Process Economics should directly support and lead to the Baseline Plant Design. The Baseline Plant Design serves as a reference for measurement of the risk inherent in projecting the current state of knowledge to full plant conditions. The plant design for each process is based on primary enrichment deployment of each technology. The minimum plant requirements to be satisfied by the design are listed in Table 2.1.

Table 2.1

MINIMUM BASELINE SEPARATION PLANT
REQUIREMENTS

ITEM	REQUIRED PLANT VALUE
Separation Capacity	Nominal 9 million SWU/yr.
Product Assay	3.2% ^{235}U or greater
Tails Assay	.08 to .12 ^{235}U
Feed Assay	0.711% ^{235}U
SWU Cost*	Less than $30/SWU

*This minimum SWU cost is to include any difference in the cost associated with the preparation of the metal feed stock for AVLIS or PSP.

The assessment of the plant design will be based on the point system shown in Table 2.3. The overall plant design has been broken into six subsystems which are assigned starting points weighted on the basis of their effect on unit cost of separative work at the baseline.

Definitions of the subsystem are presented in Table 2.2.

It is recognized that the plant design, being a paper study, represents how the technology might evolve based on the information available today. Therefore, excessive detail on the baseline plant design is not warranted. However, since the baseline plant will serve as the reference point for the risk analysis, it is important that the plant concept be defined in sufficient detail to establish a credible capital cost estimate and to evaluate the design as an integral system including the aspects of operability, reliability, and maintainability.

To determine the quality of the design effort each subsystem will be evaluated from the following points of view:

o Components Definition
Are all components defined in sufficient detail to identify requirements such as heat removal, floor space, utility requirements, etc.?

- Equipment Integration
  Are interface requirements of components specified?

- Operational Requirements
  Was plant designed with operability as an integral part of design or was it included as an after thought?

- Maintainability
  Was plant designed with maintenance as a integral part of the design? Are facilities included in the design to rework equipment? Is the layout consistant with the assumed failure rate?

TABLE 2.2

DEFINITION OF SUBSYSTEMS

FEED SOURCE

The direct source of process feed plus any auxiliary power supplies and equipment necessary to put the feed in the proper state required by the separation process and any equipment and maintenance necessary to maintain the feed rate at the desired level.

INTERACTION REGION AND PROCESS CHAMBER

The immediate structure necessary to house the process, equipment necessary to perform effective separation. This definition includes all maintenance equipment and facilities required for operation of the process chamber as well as all process physics.

ELECTROMAGNETIC SIGNALS

For the laser based processes this shall mean all oscillators, amplifiers, power supplies, multiplexers, beam conditioning, transport and steering optics necessary to generate the proper pulse rates and fluences at the point where the beams enter the process chamber. For the PSP process the term electromagnetic signals means the RF generator and excitation coil assembly. All maintenance equipment and facilities necessary to keep the electromagnetic signals on line are included in this definition.

TABLE 2.2 (Continued)

DEFINITION OF SUBSYSTEMS

EXTRACTOR/COLLECTOR

All equipment and process physics necessary to collect product and tails material. This is meant to include all equipment necessary for the collection and treatment of side streams and maintenance equipment and facilities for refurbishing collector parts.

INTERSTAGE EQUIPMENT

All equipment necessary for process stream cleanup, refluorination, recompression, casting, and transport between process stages and all maintenance equipment required.

BALANCE OF PLANT

The term defines all elements of plant and maintenance facilities not included in the previous categories. Balance of plant shall include the process buildings, cooling water requirements,electrical switchyard, transformation, distribution systems, gas liquifaction plants, all chemical conversion facilities, recycle stream processing systems, and disposal systems for waste streams as required for a process. Also all control and data acquisition elements for the plant and all control and data acquisition elements for specific subsystems.

The plant subsystems listed in Table 2.2 are to be graded according to the quality of the design and criteria listed in Table 2.3.

The Systems Importance Weighting Factor, as identified in Table 2.3, will be determined by January 30, 1982 upon issue of the large plant studies. As an example, the score for the feed source would be calculated in the following manner:

$$\text{SCORE FOR FEED SOURCE} = X_1[Y_1{*}QF_{\text{COMPONENT DEFINITION}} + Y_2{*}QF_{\text{INTEGRATION}} + Y_3{*}QF_{\text{OPERATIONS}} + Y_4{*}QF_{\text{MAINTENANCE}} \quad Y_5{*}QF_{\text{SAFETY}}]$$

TABLE 2.3

BASELINE PLANT DESIGN EVALUATION SHEET

PROCESS ______________________

		FEED SOURCE	INTERACTION REGION AND PROCESS CHAMBER	ELECTROMAGNETIC SIGNALS	COLLECTOR	INTERSTAGE EQUIPMENT	BALANCE OF PLANT
System Importance Weighting Factor		X_1	X_2	X_3	X_4	X_5	X_6
EVALUATION CRITERIA	EVALUATION CRITERIA IMPORTANCE						
1. Component definition and requirements	Y_1						
2. Level of design details and integration	Y_2						
3. Operational requirements and characterization	Y_3						
4. Maintenance plan and facility definition	Y_4						
5. Safety analysis	Y_5						
Point Sum							

Maximum Score / Awarded Score

TOTAL POINTS ________

TOTAL POINTS DIVIDED BY
EQUALS FINAL SCORE ________

Quality Factor for Baseline Plant Design

Design Quality Factor %	Superior	Adequate	Marginal	Inadequate
	75-100	50-75	25-50	0-25

2.2 Development Module Design

In the course of the AIS program, each process proponent working closely with UCC/MD has been responsible for designing a process "development module." These development modules will be the first significant scale up of the respective technologies wherein all process science and integration issues are active.

Each proponent working with UCC/MD is responsible for submitting a document which describes the development module design. The evaluation of this design will closely parallel the evaluation of the Baseline Plant design except the emphasis will be placed on specific process active subsystems and the role of the DM. The elements to be evaluated for each development module design are listed in Table 2.4.

The same definitions that were presented in Table 2.2 apply to the subsystems listed in Table 2.4. The subsystems listed in Table 2.4 are to be evaluated according to the system importance weighting points, evaluation criteria importance, and quality of the design as specified in the table. The method of assigning a score for each criteria and each subsystem proceeds exactly as described for the Baseline Plant design.

TABLE 2.4

DEVELOPMENT MODULE EVALUATION SHEET

PROCESS ______________________

		FEED SOURCE	INTERACTION REGION AND PROCESS CHAMBER	ELECTROMAGNETIC SIGNALS	EXTRACTOR/ COLLECTOR	INTERSTAGE EQUIPMENT
System Importance Weighting Factor						
EVALUATION CRITERIA	EVALUATION CRITERIA IMPORTANCE					
1. Component definition and requirements	Y_1					
2. Level of design details and integration	Y_2					
3. Operational requirements and characterization	Y_3					
4. As a step to production plant	Y_4					
Point Sum						

Maximum Score / Awarded Score

TOTAL POINTS DIVIDED BY

EQUALS FINAL SCORE__________

Quality Factor for Demonstration Module Design

Design Level	Superior	Adequate	Marginal	Inadequate
Quality Factor %	75-100	50-75	25-50	0-25

3.0 Process Performance and Risk Evaluation

The intent of this section is to permit the PEB to arrive at a full understanding of the status of each process relative to the requirements for a nominal 9 million SWU/yr plant. Evaluation scores should reflect the degree of risk involved in scaling a process from what has been experimentally demonstrated to a full scale enrichment plant.

3.1 Preprototype Performance and Integration Experiments

This subsection will focus on the highest levels of process integration that have been achieved for the three contending AIS processes. If a given process has achieved a fully integrated demonstration in a subscale facility and the equipment is truly a scaled-down version of plant components and the measured parameters have the values that are required for the baseline plant, that process should receive a higher score than a process whose performance is derived from a combination of isolated experiments. If the measured parameters are less than those required for the baseline plant, then the ratio of these values to those for the baseline plant will provide an indication of the remaining scaling required for process implementation. However, the ratio is not necessarily a good measure of the difficulty of the development task. Each case must be evaluated independently. Parameters which define physical size should be compared to the plant parameters for the largest replicable separation module or separation stage. This subsection is divided into two levels of system integration. The first is referred to as "preprototype performance" and the second is referred to as "integration experiments." A process preprototype is a subscale system wherein the feed source, interaction zone and process chamber, electromagnetic signals, enriched product collector, and tails collector operate simultaneously. The process physics of all subsystems in a preprototype should be the same as the process physics for a process module or a stage of a baseline plant. A successful preprototype demonstration by a process proponent will reduce the risk of projecting to full plant performance.

The integration experiments represent the highest levels of system integration that have been achieved in laboratory scale experiments or partial integration experiments. The experimental equipment need not be subscale plant components nor do all subsystems have to be present. The experimental data should, however, address some integration issue such as subsystem scaling effects on integration which are not treated as completely in the preprototype experiment. For an integration experiment, the closer the subsystems are to faithfully reproducing plant physics and design concepts, the more credible will be an extrapolation of the performance to full scale.

3.1.1 Preprototype Performance

Each process proponent is responsible for submitting a document which describes their preprototype design, operation characteristics, measured measured performance, and scale relative to equipment in a full scale plant. The evaluation in this section will be based on the contribution of the preprototype to reduction of risk in scaling to baseline plant conditions. The scoring will include an evaluation of the degree to which the preprototype subsystems represent subscale plant units and the performance of the preprototype relative to the largest module or stage in a full scale plant. Considerations which are important in evaluating the preprototype systems are summarized below:

1. The level of subsystems integration that has been achieved. Are the basic separation elements of a plant module or stage present?

2. Degree to which the preprototype subsystems represent plant module or stage equipment. Are there subsystem substitutions or modifications that are not representative of plant equipment?

3. The degree to which the physics of the preprototype system will duplicate the physics in a module or stage in a full scale plant. Are all pertinent physics active in the preprototype or are issues neglected or altered by equipment substitution?

4. Is the level of performance of the preprototype at or below predicted or expected values?

5. Is the scale of the preprototype significant relative to what is required for a module or stage in a full scale plant?

For items 4 and 5, Table 3.1 presents a list of suggested performance parameters which the PEB may use to judge the performance of a given preprototype.

TABLE 3.1

SUGGESTED PERFORMANCE PARAMETERS FOR EVALUATING PREPROTOTYPE PERFORMANCE

	PREPROTOTYPE SYSTEM		
PERFORMANCE PARAMETER	EXPERIMENTAL VALUE	DESIGN VALUE	PLANT VALUE
Uranium throughput			
Separative capacity			
Process interaction zone size			
Enrichment Parameters			
Process cut			
Run time			

Based on the above considerations the PEB is to arrive at an evaluation of the reduction in scaling risk supported by the level of integration and performance of a specific preprototype. Table 3.2 is a listing of the specific risk reduction levels to be used witn an assigned percentage range for awarding a score.

TABLE 3.2

RISK REDUCTION OF INTEGRATION AND SCALING TO

THE BASELINE PLANT BASED ON PREPROTOTYPE EXPERIMENT

RISK REDUCTION	POINT PERCENTAGE RANGE (%)
HIGH	75-100
MEDIUM	50-75
LOW	25-50
VERY LOW	0-25

3.1.2 Integration Experiments

Each process proponent is responsible for forwarding documentation which describes integration experiments for his process. Such documentation should describe the experimental equipment and how it relates to plant scale equipment both in performance and design. Scaling issues should clearly be identified and the performance of the integration experiment should be documented to an extent that will permit comparison to the performance predicted for a full scale plant.

The considerations that are important in evaluating the integration experiments are:

1. The level of subsystem integration that has been achieved. Are the basic four elements of the separation process present (feed source, interaction zone and process chamber, electromagnetic signals, product collection)?
2. Is the scale of the equipment and measurements made conducive to extrapolation to baseline plant design conditions?
3. To what extent does the physics of the integration experiment duplicate the physics in a plant scale module or stage?
4. Are the measured values of the performance parameters characteristic of plant scale equipment?

3.2 Subsystem Status and Scaling

3.2.1 Data Requirements

The purpose of this section is to set forth a methodology the PEB can use to evaluate the risk of integrating components into subsystems and scaling major process subsystems to the size and performance of plant scale equipment. For this section each process proponent must provide information on each subsystem which:*

1. Defines the performance and design requirements of the baseline plant design for that subsystem.
2. Presents the experimental data base for that subsystem.
3. Shows to what extent the experimental data agrees with theory.
4. Presents an extrapolation of the current level of knowledge for that subsystem to plant scale conditions which includes the most optimistic, most pessimistic and expected values.
5. Presents the costs of the subsystem for the baseline plant design case and explains how they are derived.
6. Presents the integration issues to be addressed in combining the components of the subsystem and details how the integration will be achieved.

The evaluation of risk to be made by the PEB is taken relative to the baseline plant design.

The goal of a process proponent in this section should be to demonstrate that the data base clearly supports the contention that the process is ready for advancement to an engineering development phase, and that the scaling to a baseline plant is reasonable.

Proponents should discuss the risk associated with component integration for any subsystems not demonstrated at full scale in an integrated manner and should discuss any experience with subscale or analogous equipment which would reduce risk. Each proponent should discuss the significant operational aspects of full plant operation and justify availability assumptions. Data should also be submitted to validate various costing models including justification of learning curves and quantity discounts.

---

*It is realized that the large plant preconceptual design studies are a joint effort between the process proponent and UCC-ND engineering and that UCC-ND had the responsibility for issuing the preconceptual design study. It is also recognized that there may be disagreements on large leverage items for capital cost. Item 5 is to include these potential disagreements and the preconceptual design.

For operating costs, data should be presented on replacement and refurbishment cost including both equipment and labor. Experience based on existing maintenance facilities, time and motion studies, or operating costs on analogous equipment can be submitted.

In order to go from the current demonstrated performance to the anticipated plant performance each process must scale numerous subsystems in terms of parameters such as production costs, performance, degree of integration, operating environment, or lifetime. The proponent must explain and justify each of these required subsystem scalings. The scaling must be justified to at least the baseline plant requirements, but further projections may also be presented. The accuracy of the techniques should be discussed and potential errors estimated.

The major subsystems to be considered are:

Feed Source
Interaction Zone and Process Chamber
Electromagnetic Signals
Extractor/Collector
Interstage Equipment
Balance of Plant

The minimum data required for each of the three contending processes is listed in Appendix A. In all cases of data presentation, whether tabular or graphical, the baseline plant design value is to be included as a reference point along with the DM and offline development in the DM time frame. In all cases, experimental data will be accompanied by error bars to indicate the experimental accuracy of the measurement and where applicable the predictions from the process model or appropriate submodel will be included on the same graph.

3.2.2 Subsystem Risk Evaluation and Scoring

Based on all of the information presented in the previous section the PEB is to arrive at an evaluation of the risk involved in projecting to a baseline plant design.

The maximum points associated with each subsection will be based upon the influence of process performance and cost parameters of the subsystem upon the cost of separative work for the overall system. A weighting method utilizing the UCC-ND economic codes and the multivariable sensitivity analysis will be developed and approved by the PEB. It will be the responsibility of the PEB to specify the values of the minimum, mode and maximum parameters values used in calculating the overall performance distribution functions, from which the subsystem sensitivities are derived and the maximum points in Table 3.3 are established.

TABLE 3.3

Maximum Points* for Major Subsystems

SUBSYSTEM		PROCESS	
	AVLIS	MLIS	PSP
Feed Source			
Interaction Zone and Process Chamber			
Electromagnetic Signals			
Extractor/Collector			
Interstage Equipment			
Balance of Plant			

*Preliminary TBD - Final values will be determined by January 29, 1982, upon completion of large plant studies.

The points shown for each major subsystem are to be awarded based on the overall confidence the PEB assigns to the subsystem.

Table 3.4 lists confidence conditions ranges for various levels of status and Table 3.5 lists confidence conditions for major cost drives. The relative importance of cost and performance varies between subsystems, therefore the relative importance of the two confidence factors in determining the overall confidence factor is left to the judgement of the PEB.

TABLE 3.4

Confidence Factors for Evaluating the Risk of Major Subsystem Scaling to Baseline Plant Conditions

CONDITION

1. Full size subsystem operating in a plant environment. No scaling required.
2. Subscale subsystem operation at plant design values of most parameters. Integration and scaling to larger sizes is straightforward.
3. Subscale subsystem operation at conditions off design from a plant. Achieving full plant design conditions requires further but limited development.
4. Subscale subsystem operating at conditions off design from a plant. Achieving full plant design conditions requires significant further development.
5. Components of subsystem operating in isolated tests. Integration not demonstrated but is straightforward. Scaling laws tested.
6. Components of subsystem operating in isolated tests. Integration not demonstrated and offers significant problems. Scaling not straightforward.
7. Physics of subsystem components demonstrated. Subsystem designed.
8. Physics of subsystem based on extrapolation from similar applications at different conditions. Subsystem designed.
9. Subsystem concept based on theoretical extension of physics. No detailed designs or experiments.
10. Subsystem requirements established. No experiments. No detailed designs. New technology required.

TABLE 3.5

Confidence Factors for Evaluating the Risk of Major Subsystem Costs Exceeding Baseline Plant Values

CONDITION

1. Full scale equipment produced and delivered in quantity.
2. Full scale equipment delivered or commercially available for limited number. Bids received for quantity.
3. Full scale equipment delivered or commercially available for limited number. Cost estimated for quantity.
4. Subscale equipment delivered or commercially available for limited number. Bids received for quantity at full scale.
5. Subscale equipment delivered or commercially available for limited number. Cost estimated for quantity at full scale.
6. Similar equipment manufactured. Costs based on specifications.
7. Cost estimates based on designs.
8. Cost estimates based on general costing rules.

Table 3.6

Process ____________

Subsystem Evaluation Sheet

Subsystem	Performance Confidence Factor	Costing Data Confidence Factor	Subsystem Confidence Factor	Maximum Possible Points	Point Award
Feed Source					
Interaction Zone and Process Chamber					
Electromagnetic Signals					
Extractor/Collector					
Interstage Equipment					
Balance of Plant					

Total Points = ______

The tables cannot cover all possible combinations of data available on various subsystems, but they do provide general guidance against which individual data packages can be judged. For lifetime estimates data taken for short periods should be treated as off design data and the scaling to expected lifetimes must be judged similar to any other performance parameters. Measurement of basic lifetime limiting mechanisms will be treated as off line experiments.

The total point score for subsystem and scaling will be arrived at by multiplying the overall confidence factor assigned to each subsystem by the points assigned to that subsystem in Table 3.3 and adding the points as indicated in Table 3.6.

3.3 System Integration Analysis

This section deals with estimating the risk and performance degradation associated with integrating all full scale subsystems into a full scale system.

Studies should be presented which show how major subsystems, as identified in Section 3.2, will be integrated in a plant environment and how both subsystem and system performance will be modified during integration. These studies should discuss how integration effects have been measured with current subscale subsystems and how effects scale to plant size. Effects which can not be measured in current size test beds should also be discussed. Estimates of plant availability should be presented and estimates should indicate how subsystem availability influences plant availability and performance.

A maximum of points has been allocated for the degree to which system integration analysis reduces the risk of predicting and scaling to full plant conditions. Table 3.2 will be used to evaluate the level of risk reduction.

4.0 Economic Benefits Evaluation of Baseline Plant

4.1 Assumptions

Proper assessment of an AIS process requires some measurement of the future monetary benefits which justify expenditure of research and development funds. The correct measure must contain the element of time (the time value of money and the use of a proper figure of merit). For measurement of a figure of merit, the unit cost of separative work ($/SWU) has traditionally been used and has the advantage of usually being independent of the particular separation task defined. Since the ultimate end use of enrichment plant product is in fabricated nuclear reactor fuel, the unit cost of 3.2 percent U-235 product, with its feed, conversion and separative work components, is also a useful figure of merit, however, it has the disadvantage of being most heavily weighted by the cost of ore concentrate. In previous economic analysis the cost of preparing the uranium metal shapes required by atomic vapor AIS processes have not been included in the separative work cost since they are not an inherent part of the separation process (enrichment is traditionally treated as a "TOLL" process in which the same chemical form, UF_6, is received and shipped and only the cost of separation is charged to the customer). For AIS, however, only the MLIS process fits this approach. In order to fairly assess all three AIS processes, the AVLIS and PSP unit cost should include the additional capital facilities and/or operating cost required to convert the raw feed (uranium metal "derbies") to specified feed forms and the differential cost of preparing these uranium metal "derbies" from ore concentrate over that of preparing UF_6 from ore concentrate. In addition, any incremental costs in the conversion of UF_6 or U into UO_2 will be included.

A more detailed discussion of the economic assumptions, approved by the PEB is presented in Appendix B.

4.2 Calculation of Benefits

Benefits from the deployment of an AIS technology are not derived from figures of merit alone but rather they arise from differences in these figures of merit from those of competing or existing enrichment technologies. The Department of Energy is spending present dollars on an R&D program in the hope that an improved technology will cause fewer future dollars to be spent. The potential benefit to be obtained is calculated as the present value of these future expenditure differences. For this reason the year of AIS process deployment becomes an important factor. The pattern of future development and implementation funding will also have a major impact on process deployment. The figure of merit used to determine points for the economic benefit will be related to the net present value of projected savings offered by each technology.

The baseline plant considered in this section represents our best understood plant technology and an estimated cost, projected at the time a process would begin production. The chance that these goals may not be reached due to performance, scaling or cost uncertainty constitutes the risk associated with a process which is evaluated in the other sections.

The economics benefits of the AIS program have been previously summarized in Table 1.1. Factors which affect these benefits, within a fixed nuclear power projection are:

- Technology deployment date
- Deployment rate
- Cost of alternatives (Gaseous Diffusion and Advanced Gas Centrifuge)
- SWU cost of AIS technology
- Normal feed sale floor
- Future development cost

The optimum tails assay (assay resulting in the lowest cost for the sum of ore cost and SWU cost) for an enrichment complex is based on the cost of the last incremental SWU addition. Since this optimum is flat, other issues such as the ability to raise construction capital and restraints on the mining and milling industry will be used to determine the length of time required to reach the optimum tails assay. Table 4.1 presents the assumptions for the above independent variables.

Assuming a nuclear power projection of 250 GWe by the year 2000 and completion of the 8.8 million SWU Portsmouth Gas Centrifuge Plant the economic benefit of each AIS technology will be calculated through the year 2010 and discounted to FY 1982 using a 10 percent discount factor. Each program (LANL, LLNL, and TRW) participant should devise a strategic deployment plan which best fits their technology by showing how individual process modules or cascades are designed to accommodate the market place requirements. Specifically, how does each technology offer the flexibility of producing a range of product assays, accept different feed assays (normal, tails stockpile material, tails assay from GCEP, and tails assay from the gaseous diffusion plant as they are phased out). The deployment plan should meet the enriched product demand requirements in each year of the campaign.

The PEB will review each participants deployment plan (including participants suggested values for the minimum, mode, and maximum parameters for variables associated with table 4.1) and establish values of the minimum, mode, and maximum parameters associated with Table 4.1 and the minimum, mode, and maximum parameters used in defining the maximum points in Table 3.3. This information will then be given to UCC-ND to determine the relative probability of the net present value savings for the three technologies, using the Monte Carlo analysis.

Table 4.1

Major Assumptions for Calculating Net Present Value of Benefits

Technology Deployment Date

Each proponent documents and justifies the rationale for deployment date.

Deployment Rate

The deployment rate will be limited by the ability of private industry to deliver special equipment (proponent must justify) or to limit the obligation of construction funds to no more than $500 million (end of FY 1981 dollars) per year. The case resulting in the lower deployment rate will be used.

Cost of Alternatives

Replace Diffusion Plants

The out-of-pocket cost of operating gaseous diffusion plants will be limited to the system average power costs. (FY 1982 costs are expected to be ~$70/SWU at 32 mills/kwh). Unit power costs for the 1990's will be calculated assuming power costs escalate at an annual rate of 2% above the national inflation rate.

Advanced Gas Centrifuge

The cost of advanced gas centrifuge (SETIV) is assumed to be $71/SWU.

Cost of Uranium Ore

The cost of uranium ore is assumed to be $78/KgU ($30/pound yellow cake).

SWU Cost of AIS Technology

SWU cost will be estimated at the baseline design point.

Normal Feed Sale Floor

Section 161V of the Atomic Energy Act of 1954, as amended, provides that the Government shall "assure the maintenance of a viable domestic uranium industry." The National Mining and Minerals Policy Act of 1970 encourages and fosters the private enterprise development of our nation's natural resources. To meet the national intent, a cap on the growth rate of normal feed material supplied by the ore producers will be established ~16,500 MTU. The rate of expansion for normal feed material will be limited to 1/2 the annual expansion of nuclear power growth.

5.0 Plan Technology Development and Production Implementation

The requirements for this section are that each process proponent must submit for consideration a program plan for the respective technology which will permit a decision in the late 1980's time frame on plant deployment which could occur in the early to mid 1990's.

Each program plan submitted must clearly show the program phases and engineering and development costs required to bring a production plant on line. The critical path should be clearly identified and the major participants, proposed management team and structure, and their program responsibilities must be identified. Cost for the programs should be reported on a yearly basis for the present through the start up of a nominal 9 million SWU/yr production plant.

A crucial step for project success is technology transfer from the winning proponent to industry and to the team that will implement the technology. A clear identification of the necessary management structure for its implementation must be presented. Each proponent should discuss their proposed project management structure, including key personnel assignments. The relative level of participation and decision making by the program participants will change as the DM program progresses, and the projected designated responsibilities should be outlined. A similar analysis should be done in order to define the role of the participants in the R&D program.

The evaluation for this section will be based on consideration of seven major areas, with points awarded in the first five.

1. Program Plan and Development Strategy
2. Proposed Management Team
3. Operational flexibility in changing product assay, feed assay, and tails assay
4. Capacity Expansion, SWU Cost vs. Capacity
5. Development of Industrial Vendor Rate
6. Engineering and Development Costs
7. Program Schedule

Risk is included in each area as part of the consideration. Points for deployment date and development costs associated with program schedule are incorporated in Section 4. The program plan should be structured to result in the earliest possible date for start up of a production plant consistent with the constraints of logical progression through a demonstration module phase and a plant demonstration facility phase. Other attributes of a good program plan are:

1. Definition of how the technology development with involvement of private industry, will proceed in logical steps from the current status to start up of a production plant.

2. Identification of major milestones and decision points.
3. Use of parallel development wherever possible to minimize time required.
4. Identification of major participants and proposed program management structure.
5. Identification of relevant experience and qualifications in constructing and operating advanced technology systems and conducting major facilities and goal oriented R&D programs.
6. Projection of reasonable expenditure rates.
7. Minimization of high technical risk components on critical paths.
8. Explanation of how issues not explicitly addressed in the DM will be resolved.

A viable program schedule should include:

1. Clear identification of the critical path.
2. Identification of lead times for major equipment and facilities purchases.

In defining the proposed management team, care should be taken to be as specific as possible in elaborating the management structure responsibilities and areas of authority. As much as possible, specific key personnel for the DM program should be shown in their respective boxes as well as the qualifications and degree of authority of the team in order to permit the PEB to judge the credibility of the proposed team and the risks they feel this team would have in implementing the program plan, schedule and costs.

Table 5.1 shows a breakdown of the points for the major areas considered in this section and provides a sheet for tabulation of award points.

Table 5.1

EVALUATION OF TECHNOLOGY DEVELOPMENT AND PRODUCTION IMPLEMENTATION

MAJOR AREA	MAXIMUM POSSIBLE POINTS	POINTS AWARDED
Development Strategy		
Operation flexibility in changing product assay, feed assay, and tails assay		
Capacity expansion, SWU Cost vs. capacity		
Development of industrial vendor base		
Management Team		
Total	15	

TOTAL POINTS AWARDED __________

6.0 Proliferation and Safeguards

6.1 Proliferation

A proliferation assessment will be prepared by an independent contractor. Each proponent should be prepared to discuss his baseline design for scenarios of both diversion of a large LEU plant for HEU production and clandestine construction of a small HEU plant using the same technology.

6.2 Safeguards

A Safeguard Assessment Report will be prepared by Brookhaven National Laboratory (BNL). The baseline plant design and supporting large plant design studies will serve as a basis for this assessment. The LASL safeguard assessment and other studies may also be submitted.

7.0 Environmental, Health and Safety

A generic environmental assessment will be prepared by Pacific Northwest Laboratory (PNL) which is in compliance with NEPA regulation. The baseline plant design and supporting large plant design studies will serve as a basis for the assessment.

APPENDIX A

DATA REQUIREMENTS FOR CONTENDING AIS PROCESSES

Table A-1

Science and Technology Base-Data Package Requirements for PSP

SUBCATEGORY	DATA REQUIREMENTS
1. Feed Source	a. Design and operation of current experimental feed source.
	b. Source plate lifetime and fraction of source plate utilized.
	c. Source yield and uniformity of source plate surface as a function of time.
	d. Direction spectrum and energy distribution of vaporized atoms.
	e. Source plate energy consumption.
	f. Fraction of vapor refluxed to source plate.
	g. Fraction of neutrals that are ionized.
	h. Energy expended per ion formed.
	i. Lifetime of RF ionization antenna.
	j. Ionization cross section for single and double ionization.
	k. Fraction of double ions formed.
	l. Scaling requirements.
	m. Integration issues.
2. Process Chamber	a. Design and operation of current superconducting magnet.
	b. Magnetic field uniformity over the plasma cross section.
	c. Charge exchange cross sections for neutral/ single ion exchange and for single ion/ double ion exchange.
	d. Hard body collision cross sections.
	e. T_5 vs drive field.
	f. T_5/T_0 vs drive field.
	g. Scaling requirements.
	h. Integration issues.
3. Electromagnetic Signals	a. Design and operation of induction drive coil.
	b. Radial distribution of drive field strength.
	c. Power consumption of drive coil.
	d. Scaling requirements.
	e. Integration issues.

Table A-1 (Continuation)

Science and Technology Base-Data Package Requirements for PSP

SUBCATEGORY	DATA REQUIREMENTS
4. Extraction/Collection	a. Design and operation of current collectors.
	b. Variation of enrichment with cut.
	c. Fraction of process stream deposited on guard tabs and support structure.
	d. Enrichment achieved in subscale experiments.
	e. Collector lifetime, cleaning requirements, replacement frequency.
	f. Collected material lost to vaporization and thermionic emission.
	g. Treatment of recycle material Scaling requirements.
	h. Scaling requirements.
	i. Integration issues.
5. Tails treatment/Staging	a. Design and operation of tails collection.
	b. Frequency of tails removal.
	c. Tails handling and storage procedure.
	c. Scaling requirements.
	d. Integration issues.
6. Process Model	a. Description of model and phenomena included.
	b. Complete listing and justification of assumptions made in developing the model.
	c. Comparisons of model predictions with experimental results. including error analysis.
	d. Comparison of model predicted enrichments with measured results for experimental performance that most nearly represents plant conditions.

Table A-2

Science and Technology Base-Data Package Requirements for AVLIS

SUBCATEGORY		DATA REQUIREMENTS
1. Feed Source	a.	Design and operation of current experimental feed source.
	b.	Feed mechanism operation and boat and E-beam lifetime.
	c.	Vaporization rates and uniformity with source length.
	d.	E-beam power requirements and boat cooling requirements.
	e.	Vapor velocity distribution.
	f.	Scaling requirements.
	g.	Integration issues.
2. Process Chamber	a.	Design and operation of background ion collector currently used.
	b.	Fraction of background ions created.
	c.	Fraction of vapor refluxed to source.
	d.	Fraction of metastables created prior to irridation.
	e.	Fraction of atoms available in the ground and 620 cm^{-1} states.
	f.	Fraction of material ionized and measured absorption cross sections.
	g.	Geometry of current radiation zone including anode and tab placement.
	h.	Means of addressing hyperfine states and measured results.
	i.	Measured charge exchange cross section.
	j.	Scaling requirements.
	i.	Integration issues.
3. Electromagnetic Signals	a.	Design and operation of current experimental lasers.
	b.	Laser pulse length, wavelength, energy, pulse rate, and beam diameters currently used.
	c.	Beam train transmission.
	d.	Efficiency and mean time between failures of current lasers.
	e.	Propagation characteristics of laser beams on resonance in process media.
	f.	Cleaning requirements of laser dyes.
	g.	Scaling requirements.
	h.	Details of fluence source multiplexing.
	i.	Integration issues.

Table A-2 (Continuation)

Science and Technology Base-Data Package Requirements for AVLIS

SUBCATEGORY	DATA REQUIREMENTS
4. Extraction/Collection	a. Design and operation of current extractors. b. Materials used and lifetimes achieved, replacement frequency. c. Measured effects of sputtering and thermionic emission. d. Fraction collected. e. Enrichment achieved with current experiments. f. Treatment of recycle material from tabs and support structure. g. Measured values of stripping efficiency. h. Scaling requirements. i. Integration issues.
5. Tails Treatment/Staging	a. Design and operation of tails collection system. b. Tails handling and storage system. c. Scaling requirements. d. Integration issues.
6. Process Model	a. Description of model and phenomena included. b. Complete listing and justification of assumptions made in developing the model. c. Comparisons of model predictions with experimental results including error analysis. d. Comparison of model predicted enrichments with measured results for experimental performance that most nearly represents plant conditions.

Table A-3

Science and Technology Base-Data Package Requirements for MLIS

SUBCATEGORY	DATA REQUIREMENTS
1. Feed Source	a. Design and operation of current experimental feed system.
	b. Nozzle designs tested.
	c. Material throughputs achieved.
	d. Uniformity of temperature, pressure and monomer number density at the nozzle exit.
	e. Scaling requirements.
	f. Integration issues.
2. Process Chamber	a. Design and operation of current process chamber.
	b. Fraction of UF_6 condensed prior to and in the process chamber.
	c. Fraction of UF_6 that can be addressed in the process.
	d. Temperature dependence of enrichment.
	e. Fraction of material in the boundary layer.
	f. Spectroscopy of UF_6 for first and second color ir lasers at process fluence.
	g. Ultraviolet spectroscopy of UF_6 with and without ir enhancement.
	h. Measured cross sections for both ir and uv lasers.
	i. Scaling requirements.
	j. Integration issues.
3. Electromagnetic Signals	a. Design and operation of current experimental lasers.
	b. Laser pulse length, wavelengths, energy, pulse rate and beam diameters used.
	c. Details of fluence source multiplexing.
	d. Efficiency and mean time between failures of current lasers.
	e. Progagation characteristics of laser beams in the process media.
	f. Gas laser cleanup requirements.
	g. Scaling requirements.
	h. Integration issues.

Table A-3 (Continuation)

Science and Technology Base-Data Package Requirements for MLIS

SUBCATEGORY	DATA REQUIREMENTS
4. Extraction/Collection	a. Design and operation of collectors.
	b. Pressure drop, loading rate and cleaning frequency.
	c. Material lost to back reaction and exchange.
	d. Scavenger gas reactions and products formed.
	e. Enrichment achieved with current experiments.
	f. Collector efficiency and replacement frequency.
	g. Scaling requirements.
	h. Integration issues.
5. Tails Treatment/Staging	a. Interstage gas cleanup requirements.
	b. Compressor requirements and design of current units.
	c. Tails treatment and storage.
	d. Integration issues.
6. Process Model	a. Description of model and phenomena included.
	b. Complete listing and justification of assumptions made in developing the model.
	c. Comparisons of model predictions with experiment results including error analysis.
	d. Comparison of model predicted enrichments with measured results for experimental performance that most nearly represents plant conditions.

APPENDIX B
OUTLINE OF UCC-ND AIS
PROCESS ASSESSMENT BASES AND ASSUMPTIONS

The assumptions and bases outlined below are intended to be utilized in the mid-FY 1982 UCC-ND assessment of the AIS processes. The information is presented in three categories: Plant Description, Guidelines for Cost Presentation, and Economic Ground Rules.

Plant Description

- The annual separative work capacity will be approximately 9 million SWU/yr (8.5 to 9.5 million SWU/yr).

- Normal assay feed will separated into an LWR fuel grade product (3.0 to 3.2% ^{235}U) and a tails stream of nominally 0.1% ^{235}U (0.08 to 0.12%).

- The plant will be the first of a kind to employ the AIS technology.

- The reference plant will be a shared site facility, located at the DOE's enrichment plant site in Oak Ridge, Tennessee.

Guidelines for Cost Presentation

- Costs will be assigned for all necessary steps from the common starting point of uranium ore concentrate and to the common end point of reactor-grade enriched oxide.

- Where commercial feed and product technology and/or facilities exist, it will be assumed that these operations will remain in the private sector, and commercial prices will be the basis for assigning costs (see next section).

- Facilities for specialized uranium handling operations not now in the private sector will be included within the enrichment plant design and cost estimate.

- Capital costs will include allowances for engineering, contingency, and interest during construction.

- The allowance for contingency will be estimated by the Engineering organization as a part of the large plant studies which have recently been initiated. Engineering will use the contingency matrix methodology applied most recently to the AIS Development Module conceptual design studies wherein appropriate contingency percentages are assigned to each second number account in the cost code of accounts. Contingency percentages range from 15% for standard equipment up to 100% for certain special facility equipment or components where limited design or high technical uncertainty exists. This analysis will be separately performed for each process by a team including the design manager, the cost engineer, and the lead design engineers.

Economic Ground Rules

- The annual charge rate on capital will be 11.02% representing a 25-year write-off at 10% per year interest rate.

- Costs will be stated in end-of-FY 1981 dollars.

- The costs of various chemical conversion steps for uranium and uranium compounds will be based on commercial prices such as those identified in the feed cost studies* recently done for the AIS program by the staff of the Paducah Gaseous Diffusion Plant. Lower costs which might result from developing and implementing advanced technology and/or from capacity increases will be treated as uncertainty analysis inputs.

- The costs of uranium ore concentrate will be taken as \$30/lb U_3O_8.

- The cost of electric power will be 30 mills/kWh.

- Operating and maintenance labor costs will be based on current ORGDP experiance.

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* Bewley, H. D., et al, Feed and Product Cost Study for Advanced Isotope Separation Processes, Union Carbide Corporation, Nuclear Division, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, February 2, 1981 (K/ET-731), UNCLASSIFIED; Carpenter, K. W., et al, Overview of Uranium Processing Technology Interfacing Uranium Enrichment Systems (U), Union Carbide Corporation, Nuclear Division, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, March 16, 1981 (K/ET-731), CONFIDENTIAL; Bewley, H. D., et al, Production of AVAIS Feed from Tails UF_6, Union Carbide Corporation, Nuclear Division, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, February 2, 1981 (K/ET-733), UNCLASSIFIED.

Senator DOMENICI. It has come to my attention that all of the competing processes are experiencing technological and scientific advances now right up to the last week.

Mr. BREWER. Just in the last few days, Mr. Chairman.

Senator DOMENICI. Now, I'm not saying that's good that it happened, or they should have done it sooner. I'm just saying I think that's available. Will that information be taken into account?

Mr. BREWER. Yes, sir.

Senator DOMENICI. You are going to give us that criteria document and we will make it part of the record.

Obviously part of the evaluation is going to be concerned with cost analyses?

Mr. BREWER. Yes, sir.

Senator DOMENICI. I don't want you to talk about anything that's obviously classified. How much can you tell us about processes involved and the degree to which this exercise has undergone review by different competing processes?

Mr. BREWER. The process for reaching a technical decision on this matter is as follows. There is, first of all, the criteria document. There is a panel under the Assistant Secretary for Energy Research, and the panel chairman is——

Mr. VOIGT. Dr. James E. Leiss, Office of Energy Research, DOE.

Mr. BREWER. They are assessing each of the three candidates against the criteria, and their recommendation is due this spring to the Under Secretary. Part of the process of going through this analysis, a major part, is peer review. In other words, Los Alamos reviews the status on Livermore, and TRW, and so on.

Senator DOMENICI. Will the economic model as it relates to cost, be subjected to peer review?

Mr. VOIGT. Yes, sir. In fact, the input into the model which is being prepared by Union Carbide, the Nuclear Division, has also been subject to the peer review process.

Senator DOMENICI. I understand, on another subject, in March of last year the Department did a safety assessment of its nuclear reactors. We have since drawn a plan of action based upon that report and have begun to implement, as I understand it, responses to those findings.

Could you summarize for the record the progress that you've made in implementing a plan, at least at this point?

Mr. CHIPMAN. Yes, Mr. Chairman. Since that time the Department of Energy has come out with explicit direction as to where the responsibility of the safety of these reactors lie, and that responsibility ultimately rests with the program. Almost all of the reactors are within the Nuclear Energy Program Office.

A major concern of the original report you are referring to was a lack of clear definition of who was responsible. That has been taken care of.

In addition, there is an independent safety organization within the Department that has been organized to provide input to the Secretary, Deputy, and the Under Secretary to assure that there is a checking mechanism in a similar way that it's done in NASA. They have an independent organization for this purpose, and there are a lot of details involved in both this independent group and within NE. We have an organization which is also focused on the safety of the facilities.

I guess it's best to say that we have made significant progress in resolving the issues raised by the report. Our safety record still is outstanding. I believe.

Senator DOMENICI. Is there anything you might provide us for the record on that?

Mr. BREWER. Yes, sir. I don't know if you have the patience to print all of it, but we have about 8 volumes or 10 volumes of manuals, but we will give you a summary.

[The information follows:]

SAFETY ASSESSMENT OF DOE NUCLEAR REACTORS

Soon after the occurrence of the Three Mile Island (TMI) accident, DOE program directors initiated special assessments of the safety aspects of DOE-owned facilities. In October 1979, a committee was established by DOE to evaluate personnel training, since it was apparent that operator errors were a major cause of the TMI accident. This committee was the Nuclear Facilities Personnel Qualification and Training Committee (NFPQT). The scope of this committee was expanded in November 1979 to include an assessment of all the elements included in the Kemeny report of the TMI accident. The NFPQT report was issued in March 1981. The DOE response to the report was an Action Plan issued in May 1981.

Substantial progress has been achieved in implementing the DOE Action Plan. DOE safety implementation orders have been revised and strengthened. This has included clarification of the safety responsibilities of DOE line management. Comprehensive technical assessments and reviews of DOE facilities have been conducted and the pace of improvements in plant facilities has been accelerated. Emergency preparedness response plans have received increased management attention and organizational changes have been made to provide additional independent oversight of our nuclear facilities. The Department has established a Council on Nuclear Safety to provide safety information exchange among DOE elements. In addition, training programs at DOE contractors are being increased and independent oversight of these programs has been enhanced.

Senator DOMENICI. Let me ask you about the stabilization of the inactive mill tailings program. That comes out of your military budget?

Mr. BREWER. No, sir. It's carried in the nuclear energy RD&D budget. It's not in the defense appropriation.

Senator DOMENICI. So the energy research program is going to have to pay for that?

Mr. COFFMAN. Yes, sir. NE does have a budget for the inactive mill tailings sites, which falls under the authorizing legislation for the mill tailings, Public Law 95-604.

Senator DOMENICI. When we authorized that I'm not sure of the funding level. It's estimated at about $200 million. I have seen nothing official and maybe it's too early, but can you bring us current on what the estimates are that that might cost. Do you have such?

Mr. COFFMAN. Yes. We have rough cost estimates that we are generating which are contingent upon the pending finalization of the EPA standards for the mill tailings. The cost could vary by as much as 50 percent, depending upon the standard which is finalized by EPA. We are working intensively with them to provide the economic trade-off data as a basis for their finalization in the next few weeks.

Senator DOMENICI. You say the parameter could be 50 percent higher. This Senator heard that may go as high as $1 billion; was I hearing something that was a rumor or a speculation? Where did I get it? I can't even remember where I got that.

Mr. **Coffman**. It depends on how restrictive the standards are, particularly the portions of the standards that involve controlling radon flux from the ground. That relates directly to how many cubic yards of dirt are placed over the tailings. That standard also applies to the active mill tailings as well. Vis-a-vis the amendment that you are introducing. In 1981 dollars, the total cost of the program can range anywhere from $200 to $600 million; depending upon how restrictive those standards are set.

Senator **Domenici**. Are you using consultants to do this up front work?

Mr. **Coffman**. Yes, sir. We have the Sandia National Laboratories as an interim operating contractor to assist us in the studies and review of the sites specified under the act. The Ford Bacon and Davis Utah Engineering Co. is also participating and they have prepared reports.

Senator **Domenici**. Have you entered into any major consulting contracts that are predicated upon the original estimate of $200 million, that you are spending part of that estimated amount for consulting contracts?

Mr. **Coffman**. We are spending a very small portion of the estimated total cost in the study areas. Clearly it would be desirable to get an early final EPA standard by which we can then proceed with the actual procurement and stablization of the sites.

Senator **Domenici**. I understood Bechtel was involved in a contract regarding the inactive. Are we talking about the same thing?

Mr. **Coffman**. Yes, sir. I think that's true.

Senator **Domenici**. Do you know how much that contract is for?

Mr. **Coffman**. I do not have before me the exact amount of that contract.

Senator **Domenici**. Could you get us that and just a general commitment under it?

Mr. **Coffman**. I have been advised that my statement on Bechtel was incorrect, I would be happy to submit a clarifying statement.

[The information follows:]

Bechtel is serving as the program manager contractor for the Formerly Utilized Sites Remedial Action Program (FUSRAP). We have selected the Jacobs Engineering Group, Pasadena, California as the Technical Assistant Contractor for the Uranium Mill Tailings Program and are negotiating a definitive contract.

Senator **Domenici**. I haven't talked to any members of the committee about how they interpret the stablization authorization, so I speak only for myself. I would hope that once you get the standards that you are going to have to follow, that you will then estimate the costs and that you would report back to us, informally at least, either through me or through Chairman McClure. I think we would want to take a look, even before we started letting the appropriators pay for this if this is going to come out to cost many times more than the $200 million. I don't know what anyone would do, but I think we ought to know that.

Would you consider this to be sort of a committee request that you give us the estimate?

Mr. **Brewer**. We will by all means give you the TEC when it's known with some accuracy.

Senator Domenici. In your working with EPA in an effort to get the standards, the health and safety standards set, do you have any indication when they might be ready?

Mr. Coffman. Our understanding is that their draft revised standard has been circulated within the agency, that it is at the assistant administrative level for consideration in the EPA, and that they are preparing it for issuance in final.

We are conferring at that level and providing comments on the environmental statement, which may have economic and health effects trade-offs.

The health effects from the tailings are extremely small, and we are providing detailed analyses which support the assessment of health effects. We have estimated that the EPA standards may be high by as much as a factor of 10. We have also commented on the difficulty, and as a matter of fact, and the feasibility of measuring some of the radon flux requirements associated with the proposed standards.

We are working with them to come up with a final standard our concerns reflect the high cost of the very restrictive standard, as well as the inability to show compliance with the standard. We are working intensively with them and hope that the standard can go final within the next month for our sites.

Senator Domenici. We will submit some other questions for the record.

How much difficulty would it be for you to find out from the labs that are within your jurisdiction, in whole or in part, how many fellowship or post-doctorate type people that are able to help and are putting in some training? Could you ask them that?

Mr. Brewer. Yes. We could do a survey and report that back to you and the committee.

Senator Domenici. I would be very interested, and I suspect that many members of the committee would. This is a particularly difficult time in the fields of science for someone in post-doctorate, people in for fellowships, and I'd like to see how we are doing to see if there is anything we ought to change to enhance their utilization for that kind of purpose.

Mr. Brewer. Mr. Chairman, I will be happy to do that. In fact, I would like to tell you that in the past 3 or 4 months my office initiated such a program in milling to about a half million which is not an awful lot, but it's a formal program.

Senator Domenici. Could you furnish us with the background on that?

Mr. Brewer. Yes, sir.

[The information follows:]

Fact Sheet

Title: Nuclear Science and Engineering and Health Physics Fellowship Program

Operator: Oak Ridge Associated Universities, Research Division, through Oak Ridge Operations Office

Program Summary: The program is established to help to increase the number of individuals with adequate graduate level education available to the nuclear industry. Anticipated ancillary benefits of the program include: (1) the attraction of substantial numbers of net new enrollees in undergraduate nuclear science and engineering and health physics programs, and (2) the strengthening of nuclear science departments throughout the college and university system. Fellowships are awarded for 1-year renewable terms in support of graduate study and thesis/dissertation research within the United States in the designated fields.

Specifically, the program is designed to offer a total of 24 fellowships annually to achieve a total of 36 fellowships in force annually at the steady-state level.

The program is designed to emphasize study in nuclear fuel cycle, nuclear reactor safety and safeguards, nuclear materials science and engineering, radiation interaction and detection, and health physics and radiation.

In addition to a full 9-month academic year, each fellow will be required to undertake a practicum in research and development related to his course of study at a participating center during the summer between his first and second year in the program.

Benefits: Fellows receive an annual stipend of $12,000, in monthly installments of $1,000. The students basic stipend is augmented by an allowance of $200 per month during the practicum. Initially $6,000 per year is paid directly to the university in which approved graduate study is undertaken in lieu of tuition and fees.

Costs: All costs associated with the development, implementation, and operation of the program will be borne by the Headquarters' Nuclear Energy Program budget as the fellowship program cuts evenly across nuclear energy programmatic lines.

Actual and Planned Costs

FY 1981 ($000)		FY 1982 ($000)	
B/A	B/O	B/A	B/O
146	35	489	370

Senator **Domenici**. Thank you very much to you, Mr. Secretary and all those who are with you.

We stand adjourned.

[Whereupon, at 4:40 p.m. the meeting was adjourned, subject to the call of the Chair.]

[Information submitted for the record follows:]

APPENDIX II

Answers to Additional Questions Submitted for the Record From Jan W. Mares

Senate Authorization
Subcmt. on Energy Research
and Development
3/17/82 Hearing Followup
Answered 10/26/82

Question 1: Many of the programs the Administration is proposing to terminate are of primary interest to the regulated electric and natural gas industries. How do you expect regulated industries to respond quickly to pick up this research?

Answer: The Department of Energy recognizes that, generally speaking, the regulated electric and natural gas utilities are experiencing some financial hardship which may preclude them from conducting long-term, high-risk R&D. DOE's Fossil Energy Research and Development program, therefore, is directed towards long-term generic and technology base research and is designed to take technologies through the development stages to proof-of-concept. After demonstrating proof-of-concept, the electric and natural gas utility industries may choose to continue development and ultimately commercialize these proven technologies. This, in fact, is already occurring in many cases. For example, utilities are increasing their involvement in coal-liquid mixtures, particularly in the lower-risk applications in coal designed boilers. In addition, major projects in coal gasification for electric power production are the Coolwater project and the Allis-Chalmers project. EPRI and GRI are both heavily involved in the development of various near- and mid-term technologies. EPRI is working with AFB utility applications and GRI recently announced that their 1983 research and development budget would be increased by 40 percent over 1982, to $140 million. This reflects their response to changed Federal fossil energy policies.

DOE believes that the programs that are either being terminated or redirected are sufficiently advanced to permit private industry to take over further development and subsequent commercialization without further government involvement.

SENATE AUTHORIZATION
SUBCMT. ON ENERGY RESEARCH
AND DEVELOPMENT
3/17/82 HEARING FOLLOWUP
ANSWERED 10/26/82

QUESTION 2: THE DEPARTMENT'S SENIOR ADVISORY BODY, THE ENERGY RESEARCH ADVISORY BOARD, COUNSELED DOE THAT, "A STRONG R&D RESPONSE TO PRICE SIGNALS REQUIRES BOTH MOTIVATION AND CAPABILITY..." AND CONCLUDED THAT "...IN MANY CASES THE CAPABILITY IS SIMPLY LACKING, AND WHILE IT CAN BE DEVELOPED GIVEN TIME, THE TIME REQUIRED TO BUILD A STRONG RESEARCH ORGANIZATION IS MEASURED IN YEARS." DON'T YOU BELIEVE A TRANSITION PERIOD IS REQUIRED FOR REGULATED, PRICE-CONTROLLED INDUSTRIES TO REACT TO THE SUDDEN CHANGE IN FEDERAL POLICY?

ANSWER: THE DEPARTMENT'S SUPPORT OF R&D ACTIVITIES IN ELECTRICITY RELATED AREAS FALL INTO TWO BROAD AREAS--THOSE DEALING WITH FOSSIL ENERGY AND THOSE DEALING WITH NUCLEAR ENERGY. THE MAJORITY OF THE ELECTRICITY-RELATED R&D FUNDING IS FOR NUCLEAR ENERGY AND THE PREPONDERANCE OF THAT IS DIRECTED TOWARD BREEDER REACTOR DEVELOPMENT.

DEVELOPMENT OF THE LIQUID METAL FAST BREEDER REACTOR TO MEET LONG-TERM ENERGY NEEDS HAS BEEN THE GOAL OF THE FEDERAL CIVILIAN NUCLEAR PROGRAM FOR THE PAST TWO DECADES.

A FEDERAL ROLE IS NECESSARY BECAUSE THE COSTS AND RISKS OF DEVELOPMENT ARE HIGHER THAN THE PRIVATE SECTOR CAN BEAR, AND THE BENEFITS ARE CAPTURABLE ONLY OVER A LONG PERIOD OF TIME. THE NATION'S BREEDER PROGRAM HAS BENEFITED FROM OVER 30 YEARS OF SUCCESSFUL RESEARCH, DEVELOPMENT, AND DEMONSTRATION (RD&D) SUPPORT. THE ACHIEVEMENTS ARE PART OF A NATURAL PROGRESSION IN SIZE AND COMPLEXITY THAT WILL LEAD TO DECISIONS BY THE PRIVATE SECTOR ON BREEDER INDUSTRIALIZATION AND DEPLOYMENT.

THE FEDERAL ROLE IN THE FUTURE OF BREEDER REACTORS IS TO CONDUCT THE NECESSARY RESEARCH AND DEVELOPMENT SUCH THAT THE POTENTIAL BENEFITS OF THE BREEDER CAN BE CAPTURED BY PRIVATE INDUSTRY AT A VENTURE RISK LEVEL THAT IS CONSISTENT WITH ACCEPTABLE BUSINESS ENDEAVORS. THE RESPONSIBILITY FOR INDUSTRIALIZATION AND DEPLOYMENT WILL REST WITH THE PRIVATE SECTOR.

DOE'S FOSSIL ENERGY (FE) R&D EFFORTS, OF SPECIAL INTEREST TO THE REGULATED, PRICE-CONTROLLED INDUSTRIES, HAVE NOT BEEN ABANDONED. THE FY 1983 PROGRAM HOWEVER, HAS BEEN REDIRECTED FROM THE ACCELERATION OF THE DEVELOPMENT OF NEAR-TERM TECHNOLOGIES AND DEMONSTRATION TYPE ACTIVITIES THAT PROMOTE COMMERCIALIZATION TO THE PERFORMANCE OF GENERIC AND TECHNOLOGY-BASE DEVELOPMENT. DOE WILL CONCENTRATE ON LONG-TERM, HIGH-RISK, POTENTIALLY HIGH-PAYOFF R&D PROJECTS, AND SUPPORT SOME PROJECTS UP TO THE PROOF-OF-CONCEPT STAGE. AFTER THAT POINT HAS BEEN REACHED, THE PRIVATE SECTOR RESPONDING TO MARKET FORCES, SHOULD DETERMINE THE TECHNOLOGIES THAT WILL BE DEVELOPED FURTHER AND SUBSEQUENTLY COMMERCIALIZED. THE DEPARTMENTAL BUDGET REQUEST IS BELIEVED TO BE A BALANCED ONE THAT MAINTAINS THE MOMENTUM OF ESSENTIAL PROGRAMS AND PROVIDES THE BASIS FOR FUTURE PRIVATE SECTOR ACTIVITY BASED ON THE CONTINUED SUPPORT OF GENERIC TECHNOLOGY BASE R&D.

OF SPECIAL INTEREST TO THE ELECTRIC UTILITY INDUSTRY ARE DOE'S ACTIVITIES TO FURTHER THE TECHNOLOGY BASE DEVELOPMENT OF COAL-WATER MIXTURES, FUEL CELLS, PRESSURIZED FLUIDIZED BED COMBUSTORS, ADVANCED FLUE GAS CLEANUP SYSTEMS AND COAL PREPARATION CONCEPTS FOR ENHANCED CLEANING OF COAL PRIOR TO COMBUSTION. IN ADDITION, THE ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT ACTIVITY IS FOCUSING ON THE FUNDAMENTAL MECHANISMS ASSOCIATED WITH BURNING COAL DIRECTLY.

PFB ACTIVITIES WILL CONTINUE TO BE SUPPORTED AT GRIMETHORPE, ENGLAND. THE PROGRAM ELEMENTS THAT HAVE BEEN TERMINATED IN MOST CASES INVOLVED ACTIVITIES THAT WERE DEEMED FAR ENOUGH ADVANCED FOR PRIVATE INDUSTRY TO TAKE OVER. FOR EXAMPLE, A CONSORTIUM OF EQUIPMENT SUPPLIERS AND UTILITIES IS CONSTRUCTING AN INTEGRATED GASIFIER COMBINED CYCLE PLANT AT COOLWATER, CALIFORNIA.

IN THE AREA OF GAS PRODUCTION DOE IS CONTINUING TO SUPPORT COAL GASIFICATION. THIS INCLUDES INVESTIGATION OF NEW AND NOVEL SURFACE COAL GASIFICATION CONCEPTS AND THE DEVELOPMENT OF IMPROVED ENVIRONMENTAL CONTROLS FOR EXISTING SURFACE COAL GASIFICATION PROCESSES. IMPROVED GAS UTILIZATION IS SUPPORTED THROUGH THE FUEL CELL PROGRAM.

SENATE AUTHORIZATION
SUBCMT. ON ENERGY RESEARCH
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3/17/82 HEARING FOLLOWUP
ANSWERED 10/26/82

QUESTION 3: THE ENERGY RESEARCH ADVISORY BOARD CONCLUDED THAT, "A LITTLE OVER HALF OUR PRIMARY ENERGY FINDS ITS WAY TO CONSUMERS THROUGH THE ELECTRIC AND GAS UTILITIES, AND THE UTILITIES ARE REGULATED, PRICE-CONTROLLED INDUSTRIES SELLING THEIR PRODUCTS NOT AT FREE MARKET PRICES BUT AT CONTROLLED PRICES WELL BELOW REPLACEMENT COST. THE COMMITTEE HAS LISTENED TO MANY INDUSTRY WITNESSES TESTIFY THAT THEY SIMPLY CANNOT PICK UP THE RESPONSIBILITY FOR FUNDING IMPORTANT LONG-TERM PROGRAMS SUCH AS UNDERGROUND COAL GASIFICATION AND UNCONVENTIONAL NATURAL GAS. WHY DOESN'T DOE CONSIDER THIS IMPORTANT?

ANSWER: DOE DOES BELIEVE THAT UNDERGROUND COAL GASIFICATION AND UNCONVENTIONAL NATURAL GAS RECOVERY PROGRAMS ARE IMPORTANT COMPONENTS OF THE OVERALL FOSSIL ENERGY PICTURE IN THE UNITED STATES. HOWEVER, WE ALSO BELIEVE THAT IN BOTH OF THESE PROGRAM AREAS, IT HAS BEEN DEMONSTRATED THAT THE TECHNOLOGIES ARE READY FOR COMMERCIAL DEVELOPMENT BY THE PRIVATE SECTOR. THE TIMING OF COMMERCIAL ACTIVITY WILL BE DETERMINED BY THE MARKETPLACE. COUPLED WITH OUR POSITION THE MARKETPLACE DRIVES THE DEVELOPMENT OF THESE RESOURCES, DOE ALSO IS FACED WITH DIFFICULT DECISIONS REGARDING THE ALLOCATION OF SCARCE BUDGETARY RESOURCES. WE CANNOT AFFORD TO DEVOTE COMPARABLE RESOURCES TO EVERY PROGRAM AREA. THEREFORE, DECISIONS MUST BE MADE AS TO THE AREAS WHERE RESOURCES AND EFFORT WILL BE CONCENTRATED, BASED TO SOME EXTENT UPON THE POTENTIAL PAYOFF THAT CONTINUED RESEARCH AND DEVELOPMENT WOULD YIELD.

SENATE AUTHORIZATION
SUBCMT. ON ENERGY RESEARCH
AND DEVELOPMENT
3/17/82 HEARING FOLLOWUP
ANSWERED 10/26/82

QUESTION 4: THIS FALL IN AN ADDRESS TO THE INTERNATIONAL GAS RESEARCH CONFERENCE YOU SAID THAT, "THE MULTI-WELL TEST IS AN ACTIVITY NOT LIKELY TO BE FINANCED BY THE PRIVATE SECTOR BECAUSE OF THE HIGH TECHNICAL AND FINANCIAL RISKS. BUT FROM IT WILL COME THE TECHNOLOGY BASE FROM WHICH COMMERCIAL ACTIVITIES CAN BE MOUNTED. IT IS ONE WHICH THE NPC LOOKED AT AND HAS ENDORSED, AND IT IS ONE WHICH REFLECTS WHAT TO DEFINE AS PROPER GOVERNMENT INVOLVEMENT." WHAT HAPPENED BETWEEN LAST FALL AND FEBRUARY THAT CAUSED YOU AND THE DEPARTMENT TO REVERSE COURSE AND REQUEST NO FUNDING FOR THIS PROJECT OR, FOR THAT MATTER, ANY UNCONVENTIONAL NATURAL GAS PROJECT?

ANSWER: ALTHOUGH THERE HAVE BEEN NO RECENT DRAMATIC BREAKTHROUGHS IN UNCONVENTIONAL NATURAL GAS RESEARCH, THE SIGNIFICANT LEVEL OF DRILLING RIG ACTIVITY IN THE ROCKY MOUNTAIN AREA SUGGESTS THAT TIGHT GAS SAND DEVELOPMENT IS WELL UNDERWAY. IN ADDITION, MORE THAN 10,000 WELLS HAVE BEEN DRILLED IN THE EASTERN GAS SHALE REGION. THE PRICE FOR SHALE GAS HAS BEEN DECONTROLLED. DRILLING ACTIVITY IS PRESENTLY AT AN ALL-TIME HIGH IN THE APPALACHIAN BASIN. WITH THESE PRICE INCENTIVES AND ACTIVITIES IN MIND, THE ADMINISTRATION FEELS THAT AN EXTENSIVE FEDERAL R&D ROLE IN THIS AREA IS NO LONGER NEEDED, AND THAT INDUSTRY CAN BETTER DETERMINE ITS OWN RESEARCH PRIORITIES.

INDUSTRY (GAS RESEARCH INSTITUTE) HAS BEEN APPROACHED REGARDING THEIR INTEREST IN TAKING OVER THE WESTERN GAS SANDS MULTI-WELL EXPERIMENT SITE.

Senate Authorization
Subcmt. on Energy Research
and Development
3/17/82 Hearing Followup
Answered 10/26/82

Question 5: This Committee is trying to ascertain how much of the Fossil Energy program meets the Administration's definition of long-term, high-risk research. Since the Department originally submitted a Fossil Energy budget of $305 million and Secretary Edwards fought for this same amount all the way to the White House, isn't $305 million an accurate indication of the Department's assessment of a legitimate long-term Fossil Energy program?

Answer: The President's budget, as submitted, accurately reflects the Administration's position as to those Fossil Energy Research and Development programs that are of the long-term, high-risk, high potential payoff nature and that should be supported on the context of all the various research and other projects the Federal Government could chose to support. The President's budget request fully supports activities which are still years away from commercial application, and where the economic and technical risks to successful development are so large or so uncertain that the private sector is unwilling to undertake them. In addition, consideration has also been given to the expected returns of successful development such as the potential for significant economic and technical contributions to the industry and society as a whole in selecting specific projects to be funded in the Fossil Energy program.

Senate Authorization
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and Development
3/17/82 Hearing Followup
Answered 10/26/82

Question 6: The Committee is having difficulty understanding exactly what DOE means by "long-term research." Industry appears to define "long-term" in a much shorter time frame than the Department. Industry witnesses have indicated that research beyond five to eight years isn't generally funded because they can't see the payoff. What is your definition of long-term research, and how do you explain the huge difference between the Department's arbitrary determination and common industrial practice? What is the impact of the Department's failure to fund research between the extensive gap of common industrial practice and the Department's new policy?

Answer: "Long-term research" is regarded as those activities beyond the planning horizon on a particular industry, in part because the economic and technical risks to successful development are so large or so uncertain that the private sector is unwilling to undertake them. In addition, the expected returns of successful development should include the potential for significant economic benefits to the nation.

The term cannot be defined more precisely in a general sense. More exact definitions would vary significantly from program to program, depending in part on the planning horizon of the industry involved, the private sector financial and technical resources, and the size and complexity of individual projects. DOE does not believe there is a huge gap between the DOE and industrial conception of long-term research when it is looked at on an industry by industry basis. In addition, it should be recognized that industry's definition is not necessarily fixed, but varies depending upon factors such as interest rates, inflation, and profits. Over the past several years, when inflation and interest rates were high, many industries shorted their time horizons. As economic recovery takes place, it is likely that industry will adopt longer time horizons for their R&D programs.

In fashioning our FY 1983 budget, program managers applied the general guidance cited above to their own technology areas. For example, the Fossil Energy coal preparation program is attempting to develop technologies that would remove at least 90 percent of the sulfur and ash from high-sulfur, high-ash coal, thereby producing a fuel with an environmental quality rivaling that of fuel oil. This is significantly beyond the objectives of current industrial activity including that done by EPRI and TVA. This qualifies as a "high-potential" project, and contains sufficient risk and the potential payoff is sufficiently far in the future to prevent significant industry funding.

APPENDIX III

Answers to Additional Questions Submitted for the Record From Shelby T. Brewer

Question 1. Is the Department of Energy recovering the costs properly associated with uranium enrichment?

Answer 1. Yes, Section 161v of the Atomic Energy Act requires that the charge for enrichment services recover the government's costs over a reasonable period of time. All of the government's costs are being recovered including:

- Interest imputed on the government's investment in uranium enrichment;
- Electric power for gaseous diffusion;
- Other direct and indirect operating costs;
- Depreciation of plant and equipment; and
- All other costs, including process development, administrative costs, supplemental feed costs, and unrecovered government investments.

Question 2. What are the fixed capital costs involved? How are they apportioned? How is depreciation calculated? What rate of interest is assumed? What are the variable expenses? How are they apportioned?

Answer 2. The primary fixed capital costs are the three gaseous diffusion plants and the construction work in progress on the Gas Centrifuge Enrichment Plant. The depreciation of these assets is in accordance with established standard service lives. The undepreciated balances of all capital costs are depreciated over their remaining economic life using the straight-line method of depreciation.

The interest rate is based on the year's average rate for outstanding marketable securities of the U.S. Treasury.

Power costs represent the only significant variable expense of providing enrichment services. They are apportioned on an average production cost basis. In other words, each separative work unit contains the same amount of power cost.

Question 3.	What are the fees for uranium enrichment? How are they derived?
Answer 3.	The current charges are $130.75 per SWU for Adjustable Fixed-Commitment contracts. The charge for Requirement contracts are at $141.15 or the ceiling charge, whichever is lower. Currently, the ceiling charge is $138.37 per SWU and is therefore the effective charge. We have announced increases in these charges of $138.65 for Adjustable Fixed-Commitment contracts and $149.85 as the ceiling charge for Requirements contracts to become effective on August 21, 1982.* These charges are derived to recover all the Government's costs over a reasonable period of time by estimating costs and sales over a 10-year period to arrive at a levelized charge.

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*This has become effective as of August 21, 1982.

Question 4. What was the total amount of fees collected for each of the past five years? What were the expenses for each of those years?

Answer 4. The total revenues for FY 1981, 1980, 1979, 1978, and 1977 were $1,445-, $1,379-, $1,432-, $1,046-, and $790-million. The total expenses for these years were $1,709-, $1,365-, $1,398-, $1,209-, and $696-million.

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

FRIDAY, MARCH 19, 1982

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:45 a.m., in room 3110, Dirksen Office Building, Hon. Pete V. Domenici, presiding.

Present: Senators Domenici and Warner.

Also present: Paul Gilman and Elliot Chakoff, professional staff members; James T. Bruce, counsel for the minority; and Willis Smith, professional staff member for the minority.

Senator DOMENICI. Secretary Vaughan, I apologize for being late this morning. I do not have any opening remarks.

We have your statement. We will treat it as you desire. We will make the whole thing part of the record.

You can either give your statement or give excerpts from it, whichever you desire.

STATEMENT OF HON. WILLIAM A. VAUGHAN, ASSISTANT SECRETARY, ENVIRONMENTAL PROTECTION, SAFETY AND EMERGENCY PREPAREDNESS, DEPARTMENT OF ENERGY, ACCOMPANIED BY ROBERT DAVIES, DEPUTY ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY AND HEALTH

Mr. VAUGHAN. Mr. Chairman, I will summarize briefly the major points of the statement in my remarks this morning since you have the full statement for the record.

With me this morning to help in responding to any questions you might have is Mr. Robert W. Davies, the Deputy Assistant Secretary for Environment, Safety and Health.

As you know, the goal of the environment, safety and health program in the Department of Energy is to insure that the Department complies with all current and anticipated environmental, safety, and health statutes, regulations, and other requirements, and conducts its operations with a high quality of performance.

This program is carried out through two major components, safety programs and environmental programs. The safety programs component is comprised of three separate offices, namely, the Office of Nuclear Safety, the Office of Quality Assurance and Standards, and the Office of Operational Safety. These offices are responsible for developing both nuclear and non-nuclear safety and health policies and standards, assuring their implementation by conducting technical reviews, performing comprehensive appraisals, and by sponsoring special generic technical studies to provide guidance to the Department's technology programs and field offices.

They also provide an emergency response capability for accidents involving actual or potential releases of radioactive material to the environment from the Department's nuclear facilities or for that matter, from any other source, public or private.

The environmental programs component consists of two offices, the Environmental Analysis and the Environmental Compliance Offices, which are responsible for environmental policy development, energy-related environmental issues, analyses, and ensuring that the Department's programs and projects fully comply with the National Environmental Policy Act and other applicable environmental requirements.

The President's fiscal year 1983 budget request for the environment, safety and health program is based on the transfer of this program to the Energy Research and Technology Administration under the Department of Commerce. While the overall fiscal year 1983 budget request of $38.995 million is reduced from the fiscal year 1982 appropriation, the principal activity of assuring safety and health at operating facilities and assuring environmental compliance for applicable projects will continue. In fact, there will be an increased emphasis to improve the overall safety of departmental nuclear facilities.

This emphasis involves actions to accomplish the following—complete the first cycle of comprehensive appraisals of our DOE operations offices; expand the evaluation of NRC regulatory initiatives to assure that new safety restrictions for licensed commercial facilities where applicable are incorporated into the DOE safety policy; develop additional criteria for fundamental training of operators of nuclear reactors and other nuclear facilities, and to monitor implementation of those training programs; to expand the atmospheric release advisory capability to provide around-the-clock 30 minute responses for departmental facilities; and last, to complete prototype production and testing of improved neutron dosimeters for use in the departmental facilities.

The environmental, safety and health program to date has assured that national energy policies and agency plans, programs, and operations have effectively addressed and expeditiously resolved environmental and safety problems.

The proposed fiscal year 1983 budget request provides the resources to continue this type of assurance.

At this point, sir, I am prepared to answer your questions.

[The prepared statement of Mr. Vaughan follows:]

Testimony by William A. Vaughan to the
Subcommittee on Energy Research and Development
of the Senate Committee on Energy and Natural Resources
March 19, 1982

Introduction:

Mr. Chairman, and members of the Subcommittee, I am pleased to be here today to discuss with you the Department's Environment, Safety and Health Program. With me to assist in responding to your questions, is:

Mr. Robert W. Davies, Deputy Assistant Secretary for
Environment, Safety and Health

Organization and Missions:

The goal of the Environment, Safety and Health Program is to assure that the Department complies with all current and anticipated environment, safety, and health statutes, regulations, and requirements; and conducts its operations with a high quality of performance throughout. The Environment, Safety and Health (ES&H) program is carried out by two major components; Safety Programs and Environmental Programs.

The Safety Programs component is composed of three offices: The Offices of Nuclear Safety; Quality Assurance and Standards; and Operational Safety.

As a result of a major Departmental study on the impact of the Three Mile Island (TMI) nuclear accident, nuclear safety activities were strengthened in 1981 by several new initiatives including the establishment of an Office of Nuclear Safety. This new office, with its special focus, provides an independent overview of the Agency's nuclear operations so as to minimize risks to the safety and health of workers and the public, and to provide for adequate protection of property and equipment. This overview mission is accomplished by developing safety and health policies and standards, assuring their implementation by conducting technical reviews, performing comprehensive appraisals, and by sponsoring special generic technical studies to provide guidance to the nuclear technology programs and field offices. The sub-program also provides emergency response capability for accidents involving actual or potential releases of radioactive material to the environment from the Department's nuclear facilities, and from any other source, public or private.

The basic responsibilities of the Office of Nuclear Safety arise from the Atomic Energy Act of 1954 as amended, P.L. 83-703, which required the Department to prescribe and enforce regulations and orders to protect health and minimize damage to life and property, and exempts the Department's nuclear activities from Nuclear Regulatory Commission licensing. Further, the Department prescribes and enforces effective radiological and non-radiological occupational safety and health standards and, because of this, has not been subject to Occupational Safety and Health Administration regulation in its Government-owned, contractor-operated, nuclear facilities.

The Operational Safety Office develops environmental protection, safety, and health protection policies and standards for Departmental activities not addressed by the Office of Nuclear Safety. This program is responsible for assuring that operational safety responsibilities receive Department-level oversight and management attention. These areas include Government-owned contractor-operated facilities not subject to the Occupational Safety and Health Act; hazardous waste management; air and water pollution control; and, Department aviation operations. Also included in the sub-program is the responsibility to assure the adequacy of remedial actions undertaken by the Department to decontaminate sites and facilities contaminated by radioactive material from past nuclear operations. Covered under the remedial action responsibility are sites addressed by the Uranium Mill Tailings Radiation Control Act of 1978, and others possibly contaminated by operations of the Atomic Energy Commission or the Manhattan Engineer District. Radiological monitoring and associated work, related to former weapons tests in the Marshall Islands and at the Nevada Test Site, is also covered through this sub-program.

The Quality Assurance and Standards Office, also established as a result of the Three Mile Island study, develops and coordinates the Department's Quality Assurance, Standards, and Metrication policies, overviews the implementation of these policies, and provides assistance to Department program elements in their implementation activities.

Sections 102 and 203 of the Department of Energy Organization Act provide direction for Environmental Programs activities by requiring that the Department ".....assure incorporation of national environmental protection goals in the formulation and implementation of energy programs...." and provide for functions that include "....advising the Secretary with respect to the conformance of the Department's activities to environmental protection laws and principles...."

The Environmental Programs component consists of two subprograms: Environmental Analysis, and Environmental Compliance.

The Environmental Analysis subprogram represents the Department's interests in the Federal regulatory development process, maintains comprehensive environmental data bases to permit responsive, substantive analysis of energy-related environmental issues and conducts anticipatory analyses for early identification and scoping of emerging regulatory issues.

The Environmental Compliance subprogram provides support to assure Departmental compliance with the National Environmental Policy Act (NEPA) and associated environmental statutes and regulations. The subprogram formulates Departmental compliance policies and performs a staff-intensive service function for all Agency offices to protect the Department's programs and projects from unnecessary delays due to non-compliance with NEPA and other requirements. The subprogram analyzes the need for documentation and reviews NEPA documents to assure that standards are met.

Fiscal Year 1982 Activities:

The ES&H program, which was redirected in Fiscal Year 1981 to more strongly emphasize nuclear safety, will include the following activities in FY 82:

Safety Programs

- Complete comprehensive environmental, safety, and health (ES&H) appraisals of four of the Department's eight Operations Offices.
- Activate the Council on Nuclear Safety for exchange of nuclear safety information among the Department's operating officials and key nuclear safety personnel.
- Implement a nuclear safety training program, including criticality training, fundamentals of reactor operator training, and validation of the training process through self-evaluation.
- Support the Departmental remedial action program, by conducting timely actions to establish priorities and designate sites for the cleanup of properties contaminated with radioactive materials from past government operations; and to certify the adequacy of clean up efforts and conduct post-remedial action audits and surveys.

- o Continue medical care and radiological monitoring of the Rongelap, Utirik and Enewetak people; and complete radiation dose assessments of the remaining atolls.
- o Complete the Liquefied Natural Gas experimental test spill program.

Environmental Programs

- o Develop a NEPA compliance strategy with the Assistant Secretary for Nuclear Energy, regarding the Department's Nuclear waste repository program.
- o Assist Departmental offices in meeting NEPA and other environmental requirements, as evidenced by approximately 320 NEPA Determinations and 200 Document Reviews.
- o Conduct analyses of energy/environment impacts of environmental legislation, issues, and regulations.
- o Conduct analyses of environmental control options, especially coal or synfuel related, with respect to: wastewater treatment; fire particulate and other air emission controls; leachate control and disposal of solid waste; and joint efforts with other DOE programs on control of indoor air quality.

Fiscal Year 1983 Request

The Fiscal Year 1983 request for the Environment Safety and Health Program is shown in the tabular material below, as is the appropriations for Fiscal Year 1982.

	FY 1982 Appropriation	FY 1983 Appropriation
Operating Expenses		
Safety Programs	$32,381	$28,645
Environmental Programs	13,250	3,500
Subtotal	45,631	32,145
Program direction	7,895	5,350
Total Operating Expenses	53,526	37,495
Capital Equipment	4,000	1,500
Total Environmental Safety & Health	$57,526	$38,995
Staffing	153(2)*	90(5)*

* Parentheses indicate other than full-time employees.

The President's FY 1983 Budget request for the Environment, Safety and Health Program is based on the transfer of this Program to an Energy Research and Technology Administration under the Commerce Department. While the overall FY 1983 budget request of $38,995 million is reduced from the FY 1982 appropriation, the principal activity of assuring safety and health at operating facilities, and environmental compliance for applicable projects, will continue. In fact, there will be an increased emphasis to improve the overall safety of Departmental nuclear facilities. This emphasis will involve actions to:

- o Complete the first cycle of comprehensive appraisals at the DOE Operations Offices.
- o Expand the evaluation of NRC regulatory initiatives to assure that new safety restrictions for licensed commercial facilities, where applicable, are incorporated into DOE safety policy.
- o Develop additional criteria for fundamental training of operators of nuclear reactors and other nuclear facilities, and to monitor implementation of training programs.

- o Expand Atmospheric Release Advisory Capability to provide around-the-clock 30-minute responses for Departmental facilities.
- o Complete prototype production and testing of improved neutron dosimeters in Departmental facilities.

Certain support activities such as the safety evaluations of handling, storing, transporting and utilizing liquefied gaseous fuel; and environmental control technology assessments of developing energy systems are no longer needed and will be eliminated. Planning for reduced efforts in these particular areas stems, principally, from a conclusion that such activities can be best performed in the private sector. This is consistent with changes in other Departmental programs and, correspondingly, it can be expected that there will also be reductions in the number of NEPA document reviews and energy/environment policy analyses.

The Environment, Safety and Health Program has to date assured that National energy policies and agency plans, programs and operations have effectively addressed and expeditiously resolved environmental and safety problems. The proposed FY 1983 budget request provides the resources to continue this assurance

I am prepared to answer your questions.

Injury and Property Damage Summary

January - December 1981

Safety Performance

U.S. Department of Energy

Office of the Deputy Assistant
Secretary for Environment,
Safety and Health

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NOTICE

Effective July 1,1981, the reporting minimum for DOE losses were increased from $100 to $250 for vehicle damage and from $100 to $1000 for property loss. Thus, the 1981 experience may not be comparable to prior years` data. Bargraph captions indicate "Occurrences with $100 or More Damages" which is correct for all but the 1981 data.

INJURY AND PROPERTY DAMAGE SUMMARY
for
Calendar Year 1981

The Department of Energy made impressive gains in 1981 over 1980, the previous best safety year. Improved injury incidence rates resulted in 102 fewer lost workday injuries and 4,090 fewer lost workdays than would have occurred at the projected 1980 rates. Seven fatalities (three of which occurred in a single aircraft accident), resulted in a fatality rate of 4.6 deaths per 100,000 employees, comparable to the DOE 1976-1980 average of 4.5. One occupational fatality occurred during the fourth quarter in the crash of a privately-owned plane.

Although the fire loss rate increased over 1980's remarkably low 0.07 cent per $100 valuation, the 1981 total fire and non-fire property loss picture improved to a rate of 0.83 cent per $100 valuation which represents a savings of $1,265,000.

In 1981, the DOE experienced its best ever vehicle accident frequency rate of only 4.8 accidents per million vehicle miles. There were 30 fewer accidents and $122,806 less vehicle damage than in 1980.

Large improvements at the power administrations and the petroleum reserves, and continued improvement of excellent records by several of the former AEC field office operations, contributed to making 1981 the best safety year ever for the Department of Energy.

INJURY

During 1981, 1,430 lost workday cases and 19,379 lost workdays resulted in incidence rates of 1.0 lost work cases and 13.5 lost workdays per 200,000 work-hours. These rates are 7% and 18% below the respective DOE incidence rates for 1980. The improvement is statistically significant at the 99% confidence level. Despite this decrease, the total recordable case incidence rate was unchanged from last year at 2.3 cases per 200,000 work-hours. This apparent conflict may be the result of better reporting of minor injuries or it may be that the fraction of injuries serious enough to result in lost workdays is declining.

Injury Incidence Rates

	Calendar Year 1981	Calendar Year 1980	1976-1980 Average
Total Recordable Cases	2.3	2.3	2.7
Lost Workday Cases	1.0	1.1	1.1
Lost Workdays	13.5	17.5	17.8

There was one fatality during the fourth quarter. An employee of Lawrence Livermore National Laboratory, who was flying his privately-owned aircraft on official business, crashed in southern Utah while enroute to Colorado, on October 4, 1981. There were 7 fatalities during the year resulting in a fatality rate of 4.6 deaths per 100,000 workers compared to 4.5 for the 1976-1980 DOE average and 13.7 for the U.S. Industrial rate.

FIRE LOSS

During the fourth quarter, there were no large fires and a total of only $60,000 in losses. Two earlier fires during 1981 accounted for 91% of the total annual fire loss (the $1,250,000 Vantage substation fire and the $575,000 Naval Petroleum Reserve fire). The resulting fire loss rate of 0.38 cent per $100 valuation is not high by industry standards but is 2.5 times the 1976-1980 DOE average fire loss rate of 0.15.

NON-FIRE PROPERTY LOSS

Non-fire property losses of $2,492,000 resulted in a 1981 annual loss rate of 0.45 cent per $100 valuation or only 53% of the DOE average 1976-1980 loss rate of 0.85 cent per $100 valuation. Only one non-fire property loss greater than $50,000 occurred during the fourth quarter: a ruptured water main caused $183,000 flooding damage to an Oak Ridge research facility. Other major non-fire losses during 1981 were: damage to a UF6 cascade system from air leakage ($400,000); oil spill from a tank overflow ($338,000); oil spill from failure of pressure release system on a pump ($238,000); contaminated water backed into a laboratory from a radioactive liquid waste tank ($199,000); and collapse and damage of an air-supported building during high winds ($141,000).

VEHICLE LOSS

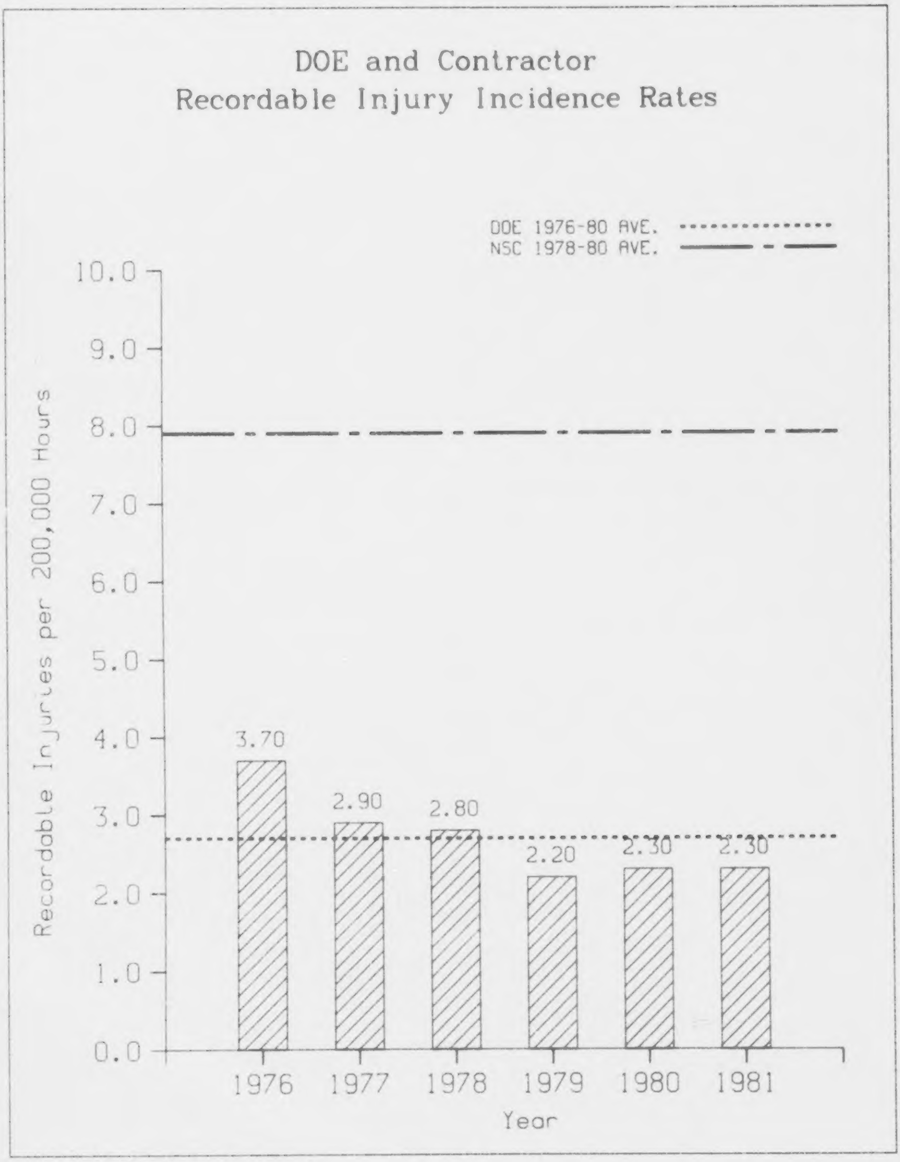
In 1981, 17,424 vehicles used in DOE operations traveled 132 million miles and experienced 632 accidents with $464,000 damages. The frequency rate of 4.8 accidents per million vehicle miles is lower than last year's rate of 5.0 and significantly lower than the DOE 1976-1980 average rate of 5.6 accidents per million miles. The 1981 dollar loss rate of $3.52 per 1,000 miles is less than the 1980 rate of $4.83, but is higher than the DOE 1976-1980 average of $3.10 per 1,000 miles.

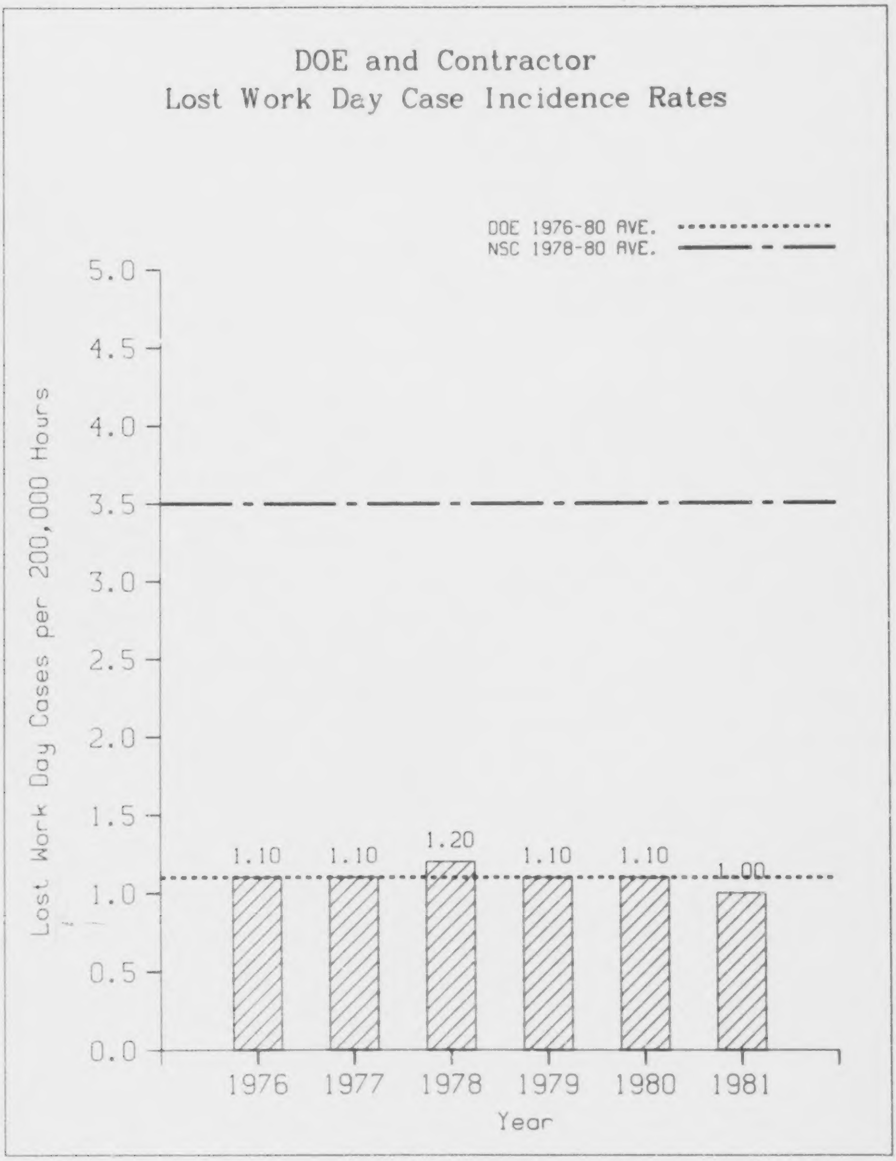
AIRCRAFT LOSS

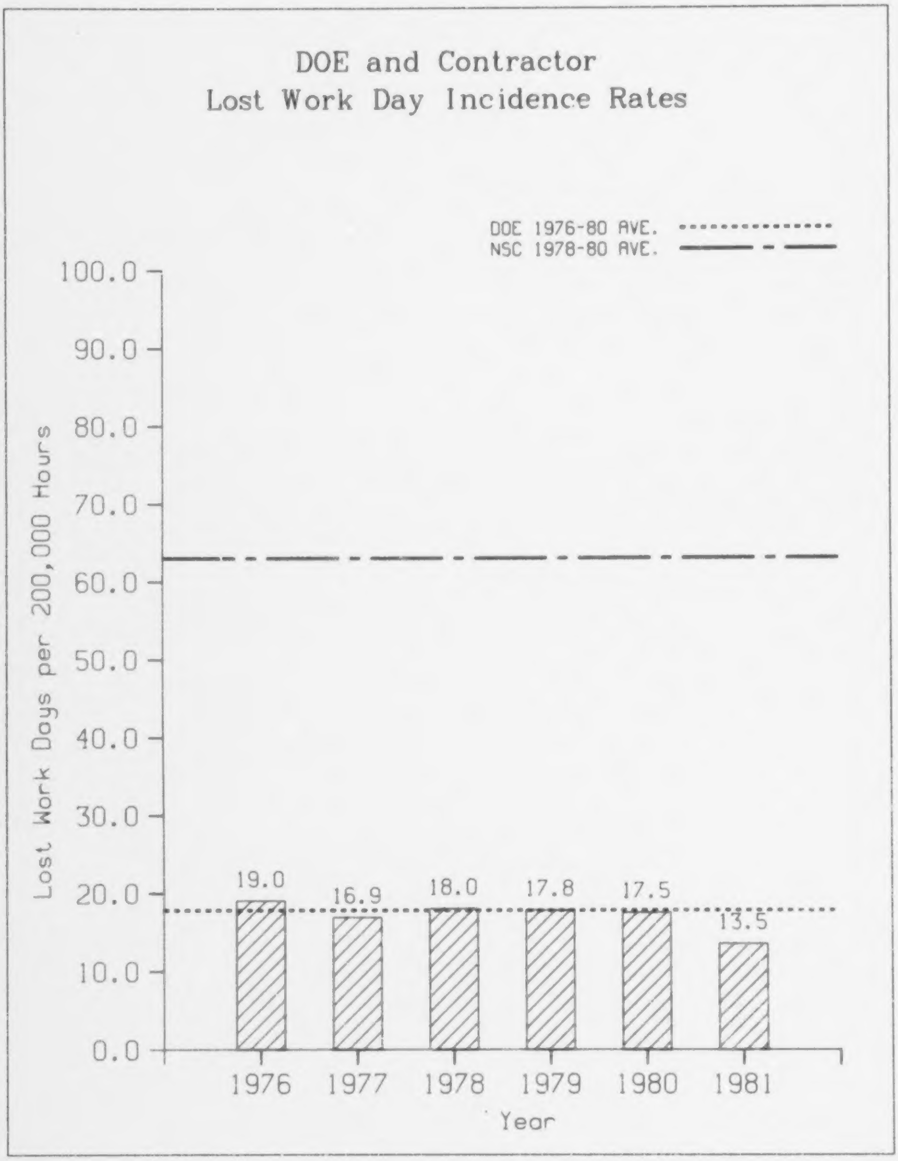
During 1981 there were two accidents involving DOE-owned or DOE-leased aircraft. One accident resulted in three fatalities, while the other resulted in only minor injuries to the pilot. A third accident occurring in the fourth quarter of 1981, resulted in the fatality of a DOE contractor employee. While on official travel, his privately-owned airplane crashed in bad weather at an altitude of 12,000 feet near La Sal, Utah. The resulting accident rates for DOE aircraft, while not statistically significant with only two accidents, are above the national average for general aviation.

MARINE, RAILROAD, AND MATERIAL HANDLING EQUIPMENT LOSS

There were no accidents reported this quarter for marine, railroad and material handling equipment.

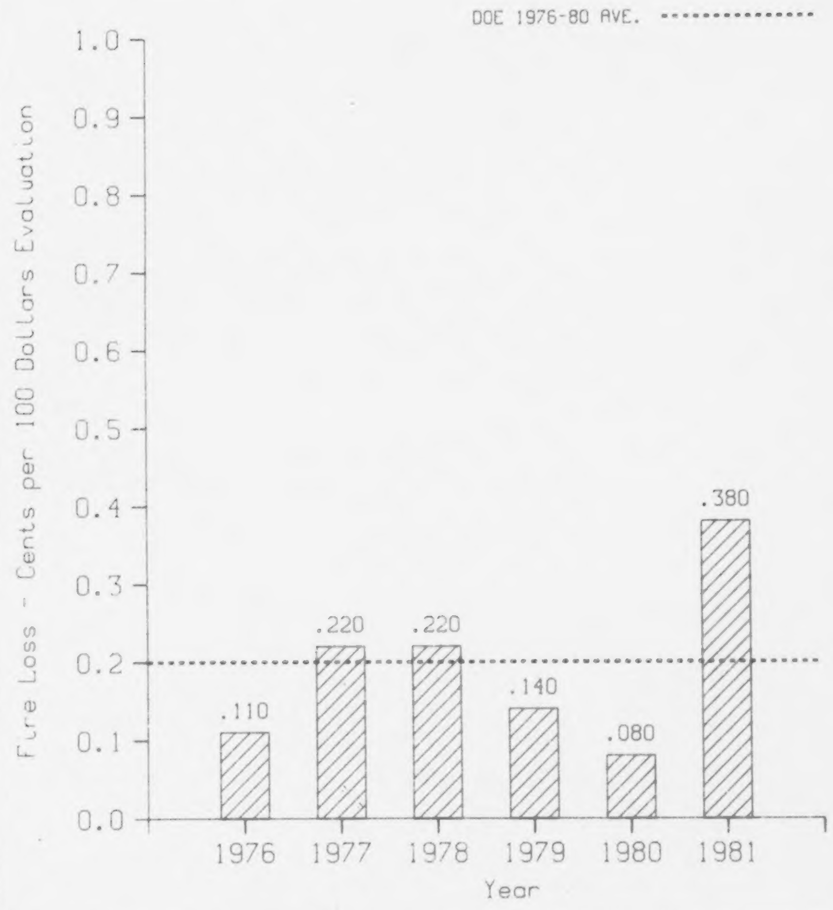

DOE and Contractor
Recordable Injury Incidence Rates
DOE 1976-80 AVE.
NSC 1978-80 AVE.
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Recordable Injuries per 200,000 Hours
3.70
2.90
2.80
2.20
2.30
2.30
1976
1977
1978
1979
1980
1981
Year

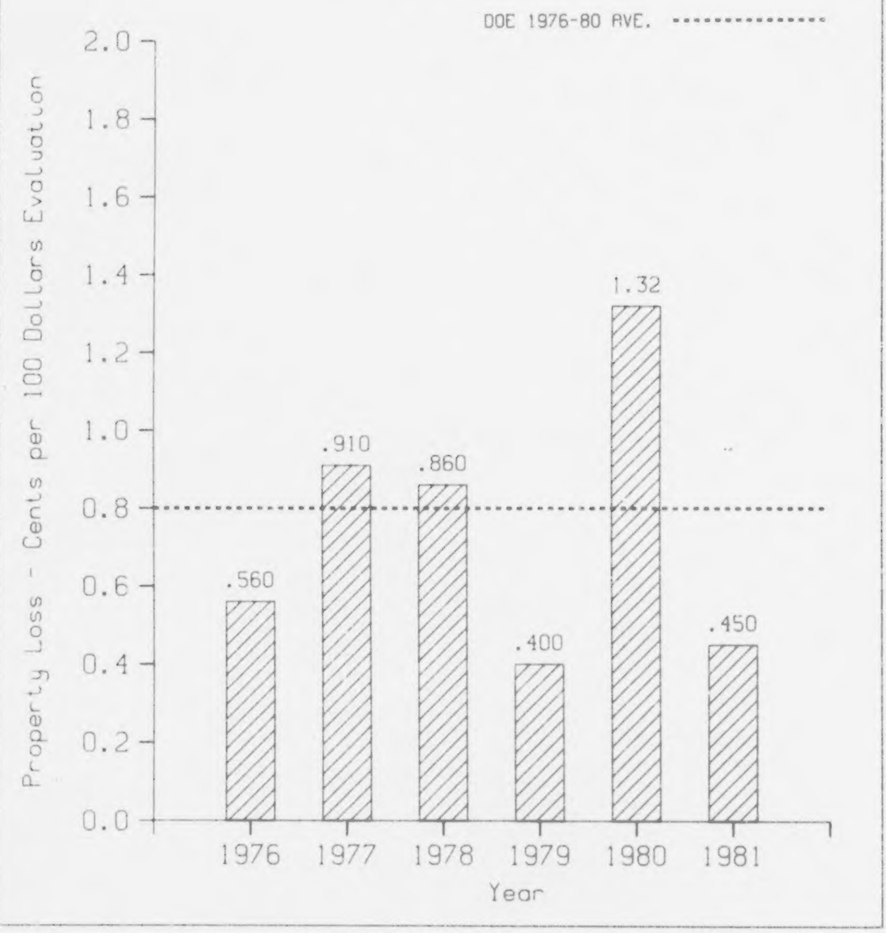

DOE and Contractor
Lost Work Day Case Incidence Rates
DOE 1976-80 AVE.
NSC 1978-80 AVE.
Lost Work Day Cases per 200,000 Hours
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.10
1.10
1.20
1.10
1.10
1.00
1976
1977
1978
1979
1980
1981
Year


DOE and Contractor
Lost Work Day Incidence Rates
DOE 1976-80 AVE.
NSC 1978-80 AVE.
Lost Work Days per 200,000 Hours
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
19.0
16.9
18.0
17.8
17.5
13.5
1976
1977
1978
1979
1980
1981
Year

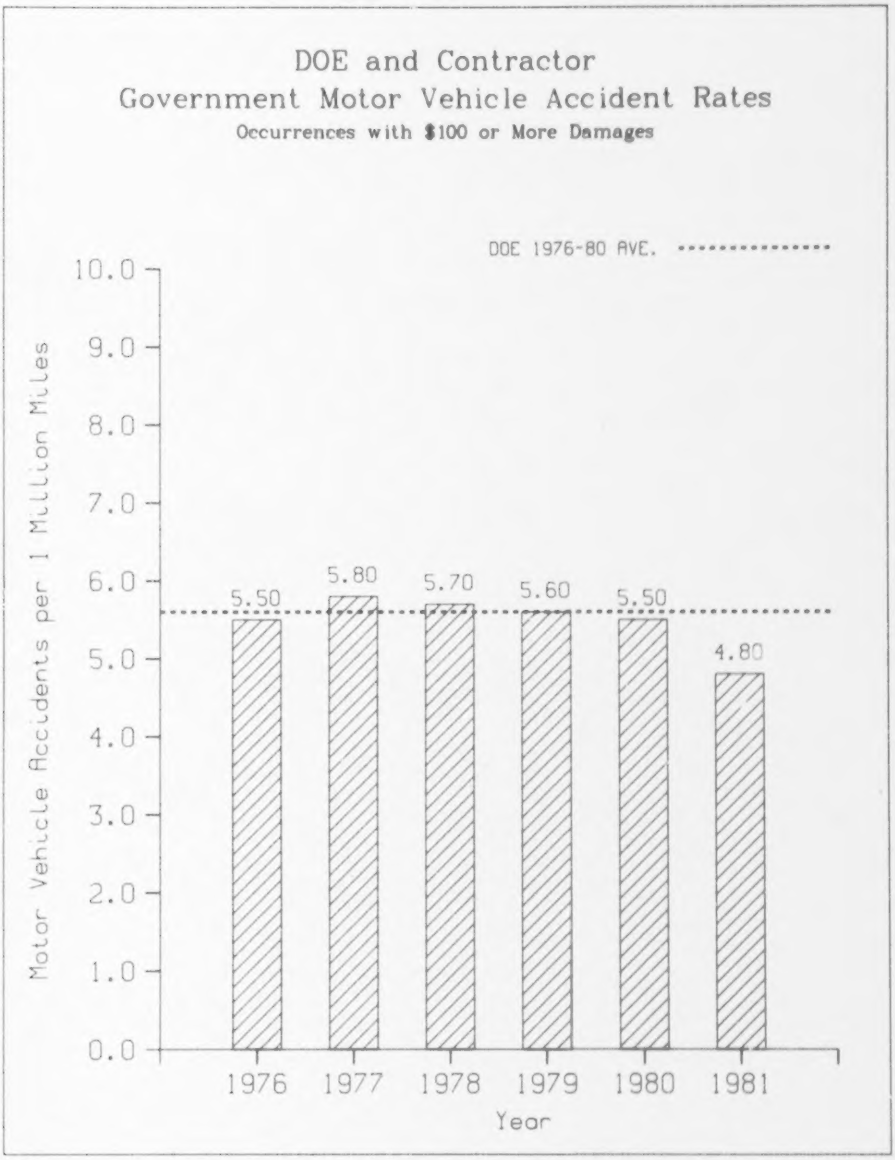
DOE and Contractor Fire Loss Rates

Occurrences with $100 or More Damages

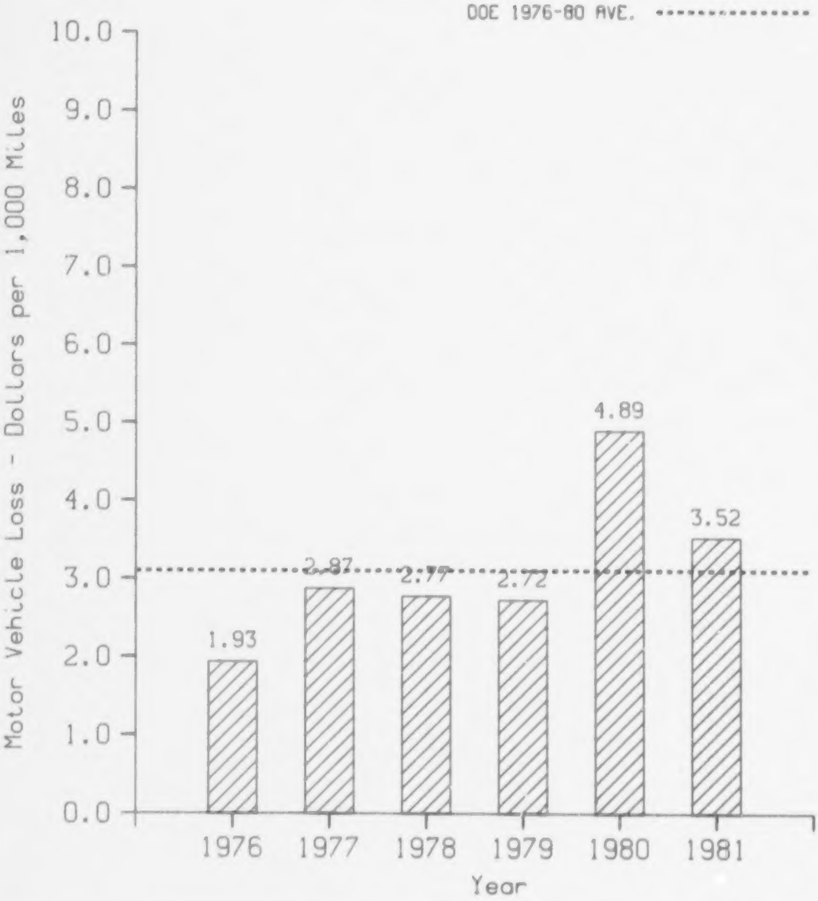




DOE and Contractor
Property Loss Rates - excluding Fires
Occurrences with $100 or More Damages



DOE and Contractor
Government Motor Vehicle Accident Rates
Occurrences with $100 or More Damages



DOE and Contractor
Government Motor Vehicle Loss Rates
Occurrences with $100 or More Damages

GLOSSARY

TRC = Total Recordable Cases

LWC = Lost Workday Cases

LWD = Lost Workdays (Away and Restricted)

Incidence Rate = Frequency per 200,000 Work-hours (100 person-years)

MVM = Million Vehicle Miles

Property Valuation = Estimated Replacement Cost

NSC = National Safety Council

The National Safety Council (NSC) data are from ACCIDENTS FACTS, 1980 edition. All NSC averages and rates printed herein refer to U. S. Industry with the exception of vehicle rates which are based on the total miles traveled by registered highway vehicles.

Field Organization abreviations used in TABLES XI, XII, and S1 through S7:

AL = Albuquerque Operations
CH = Chicago Operations
ETC = Energy Technology Centers
HQ = Headquarters (DOE)
ID = Idaho Operations
NPR = Naval Petroleum Reserves
NV = Nevada Operations
OR = Oak Ridge Operations
PA = Power Administrations
PNR = Pittsburgh Naval Reactors Office
RL = Richland Operations
SF = San Francisco Operations
SNR = Schenectady Naval Reactors Office
SPR = Strategic Petroleum Reserves
SR = Savannah River Operations

TABLE I

DOE AND CONTRACTOR LOSS DATA
1981 THROUGH 4TH QUARTER

INJURY

	NUMBER	YTD RATE	1976-80 AVERAGE RATE	NSC 1978-80 U.S. INDUSTRIAL RATE
Total Cases(1)	3304	2.3	2.7	7.9
Lost Workday cases(1)	1430	1.0	1.1	3.5
Lost Workdays(1)	19379	13.5	17.8	63.0
Fatalities(2)	7	4.6	4.5	13.7

---

(1) Rates are based on 200,000 work-hours.
(2) Fatality Rates are based on 100,000 worker-years.

PROPERTY LOSS

	NUMBER EXCEEDING $1000	DOLLAR LOSS (THOUSANDS)	CENTS LOSS PER $100 VALUATION	
	1981 YTD	1981 YTD	1981 YTD	1976-80 AVERAGE
Fire	83	2070	0.38	0.15
Nonfire	181	2492	0.45	0.85
Total	264	4562	0.83	1.00

VEHICLE LOSS

	1981 YTD	1976-80 AVERAGE
Number of Vehicles	17424	15194
Miles Traveled (millions)	132	112
Number of Accidents >$250	632	629
Accidents per Million Miles	4.8	5.6
Dollar Loss (thousands)	464	347
Dollar Loss per 1000 Miles	3.52	3.10

TABLE II

DOE AND CONTRACTOR LOSS RATES
1981 THROUGH 4TH QUARTER

FIELD ORGANIZATION	INJURY INCIDENCE RATES			PROPERTY DAMAGE	VEHICLE	
	TRC	LWC	LWD	CENTS LOSS PER $100 VALUATION	ACCIDENTS PER MVM	DOLLAR LOSS PER 1000 MILES TRAVELED
Albuquerque Operations	1.5	0.7	9.4	0.28	3.8	2.90
Chicago Operations	2.6	1.6	15.4	0.37	9.5	7.77
D.O.E. Headquarters	0.9	0.7	7.1	0.00	30.8	21.41
Energy Technology Centers	3.2	1.4	24.4	2.57	6.8	7.89
Idaho Operations	2.1	1.0	7.2	0.52	2.7	3.00
Nevada Operations	6.9	3.7	56.4	0.53	2.1	2.93
Oak Ridge Operations	1.7	0.4	7.4	0.28	4.6	1.53
Petroleum Reserves	10.3	3.6	34.2	8.98	8.3	2.48
Pittsburgh N.R. Office	0.8	0.2	8.1	0.98	4.0	7.52
Power Administrations	3.2	2.0	41.6	4.37	3.0	1.62
Regional Offices	2.6	1.3	10.3	0.00	0.0	0.00
Richland Operations	2.9	0.6	7.6	1.08	8.1	6.91
San Francisco Operations	2.4	1.1	12.8	0.32	10.7	9.32
Savannah River Operations	1.3	0.3	6.6	0.28	3.5	2.92
Schenectady N.R. Office	0.5	0.3	4.4	0.26	5.0	7.85
TOTAL DOE AND CONTRACTOR	2.3	1.0	13.5	0.83	4.8	3.52

TABLE III

DOE AND CONTRACTOR
INJURY DATA BY OPERATION TYPE
1981 THROUGH 4TH QUARTER

OPERATION TYPE	EQUIV. (1) FULL-TIME EMPLOYEES	T R C NO.	T R C INCI-DENCE RATE	DEATHS	L W C NO.	L W C INCI-DENCE RATE	L W D NO.	L W D INCI-DENCE RATE	1976-80 INCIDENCE RATES LWC	1976-80 INCIDENCE RATES LWD
Government (2)	19573	330	1.8	3	215	1.2	3473	18.8	1.0	16.5
Production	46420	610	1.4	0	164	0.4	3355	7.6	0.4	11.6
Research	63482	1027	1.7	2	535	0.9	5614	9.3	1.1	14.4
Services	7179	237	3.6	0	128	1.9	1593	23.9	1.9	28.8
Cost Const (3)	9302	552	6.3	1	237	2.7	3745	42.6	3.0	57.5
Lump Const (3)	4291	528	13.2	1	146	3.6	1551	38.7	3.8	64.9
Arch/Engr	860	20	2.5	0	5	0.6	48	5.9	0.3	3.4
TOTAL DOE	151107	3304	2.3	7	1430	1.0	19379	13.5	1.1	17.6
TOTAL NSC (1978-80)			7.9			3.5		63.0		

---

(1) Approximate numbers based on 1900 work-hours per employee per year.

(2) All DOE federal employees.

(3) National safety council LWD incidence rate is 90 for construction industries.

TABLE IV

DOE AND CONTRACTOR INJURY DATA
1981 THROUGH 4TH QUARTER

		T R C			L W C		L W D		1976-80 INCIDENCE RATES	
FIELD ORGANIZATION	EQUIV.(1) FULL-TIME EMPLOYEES	NO.	INCI-DENCE RATE	DEATHS	NO.	INCI-DENCE RATE	NO.	INCI-DENCE RATE	LWC	LWD
Albuquerque Operations	36478	509	1.5	0	251	0.7	3255	9.4	0.9	12.1
Chicago Operations	14552	362	2.6	0	219	1.6	2128	15.4	1.5	19.2
D.O.E. Headquarters	7956	66	0.9	0	50	0.7	540	7.1	0.5	6.1
Energy Technology Centers	1501	46	3.2	0	20	1.4	348	24.4	0.8	11.2
Idaho Operations	6623	131	2.1	0	61	1.0	455	7.2	1.5	23.1
Nevada Operations	7672	502	6.9	1	268	3.7	4110	56.4	3.3	58.0
Oak Ridge Operations	25498	402	1.7	0	91	0.4	1802	7.4	0.5	15.5
Petroleum Reserves	3424	335	10.3	1	117	3.6	1114	34.2	5.8	88.7
Pittsburgh N.R. Office	4431	32	0.8	0	10	0.2	342	8.1	0.8	13.7
Power Administrations	5445	168	3.2	3	105	2.0	2151	41.6	2.4	46.5
Regional Offices	164	2	2.6	0	1	1.3	8	10.3	0.2	23.9
Richland Operations	11432	318	2.9	0	67	0.6	822	7.6	0.7	14.2
San Francisco Operations	12993	302	2.4	2	137	1.1	1586	12.8	1.5	21.7
Savannah River Operations	9260	113	1.3	0	23	0.3	581	6.6	0.4	9.9
Schenectady N.R. Office	3309	16	0.5	0	10	0.3	137	4.4	1.7	15.0
TOTAL DOE AND CONTRACTOR	151107	3304	2.3	7	1430	1.0	19379	13.5	1.1	17.6
TOTAL NSC (1978-80)			7.9			3.5		63.0		

---

(1) Approximate number based on 1900 work-hours per employee per year.

TABLE V

DOE AND CONTRACTOR FIRE LOSS
1981 THROUGH 4TH QUARTER

FIELD ORGANIZATION	NUMBER OF ACCIDENTS > $1000(1) 1981	NUMBER OF ACCIDENTS > $1000(1) 1976-80(2)	GOVERNMENT DOLLAR LOSS 1981	GOVERNMENT DOLLAR LOSS 1976-80(2)	CENTS LOSS PER $100 VAL. 1981	CENTS LOSS PER $100 VAL. 1976-80(2)
Albuquerque Operations	11	12	47940	149617	0.06	0.23
Chicago Operations	5	10	54450	144478	0.13	0.44
D.O.E. Headquarters	0	1	0	180000	0.00	15.52
Energy Technology Centers	1	0	2000	20400	0.12	2.59
Idaho Operations	2	4	7700	8680	0.04	0.07
Nevada Operations	38	49	30451	32043	0.43	0.52
Oak Ridge Operations	4	4	10100	37515	0.00	0.02
Petroleum Reserves	3	2	588500	125185	3.87	1.24
Pittsburgh N.R. Office	1	0	13280	0	0.29	0.00
Power Administrations	4	2	1261150	34338	4.30	0.13
Richland Operations	6	7	33910	72454	0.08	0.16
San Francisco Operations	3	6	14200	17362	0.14	0.21
Savannah River Operations	5	14	5765	52763	0.01	0.11
Schenectady N.R. Office	0	2	0	7914	0.00	0.08
TOTAL DOE AND CONTRACTOR	83	118	2069446	656810	0.38	0.15

---

(1) DOE statistics prior to July 1981 included occurrences with $100 or more damages.

(2) Annual average.

TABLE VI

DOE AND CONTRACTOR NON-FIRE PROPERTY LOSS
1981 THROUGH 4TH QUARTER

FIELD ORGANIZATION	NUMBER OF ACCIDENTS > $1000(1)		GOVERNMENT DOLLAR LOSS		CENTS LOSS PER $100 VAL.	
	1981	1976-80(2)	1981	1976-80(2)	1981	1976-80(2)
Albuquerque Operations	54	105	188467	928500	0.22	1.42
Chicago Operations	9	21	96212	188375	0.24	0.5[illegible]
D.O.E. Headquarters	0	0	0	0	0.00	0.00
Energy Technology Centers	2	0	41000	0	2.46	0.00
Idaho Operations	10	66	86044	132468	0.48	1.03
Nevada Operations	12	37	7745	242018	0.11	3.95
Oak Ridge Operations	10	15	607669	217384	0.28	0.12
Petroleum Reserves	12	5	778104	36950	5.12	0.36
Pittsburgh N.R. Office	3	5	31490	14958	0.69	0.33
Power Administrations	34	8	20995	131453	0.07	0.50
Richland Operations	13	19	433964	937842	1.00	2.08
San Francisco Operations	2	8	17200	736648	0.17	8.78
Savannah River Operations	17	15	149011	118108	0.27	0.25
Schenectady N.R. Office	3	7	34370	63605	0.26	0.61
TOTAL DOE AND CONTRACTOR	181	307	2492271	3699984	0.45	0.85

---

(1) DOE statistics prior to July 1981 included occurrences with $100 or more damages.

(2) Annual average.

TABLE VII

DOE AND CONTRACTOR TOTAL PROPERTY LOSS
1981 THROUGH 4TH QUARTER

FIELD ORGANIZATION	NUMBER OF ACCIDENTS > $1000(1)		GOVERNMENT DOLLAR LOSS		CENTS LOSS PER $100 VAL.	
	1981	1976-80(2)	1981	1976-80(2)	1981	1976-80(2)
Albuquerque Operations	65	117	236407	1078117	0.28	1.65
Chicago Operations	14	31	150662	332853	0.37	1.02
D.O.E. Headquarters	0	1	0	180000	0.00	15.52
Energy Technology Centers	3	0	43000	20400	2.57	2.59
Idaho Operations	12	70	93744	141148	0.52	1.10
Nevada Operations	50	86	38196	274061	0.53	4.47
Oak Ridge Operations	14	19	617769	254899	0.28	0.14
Petroleum Reserves	15	7	1366604	162135	8.98	1.60
Pittsburgh N.R. Office	4	5	44770	14958	0.98	0.33
Power Administrations	38	10	1282145	165791	4.37	0.63
Richland Operations	19	26	467874	1010296	1.08	2.24
San Francisco Operations	5	14	31400	754010	0.32	8.99
Savannah River Operations	22	29	154776	170871	0.28	0.37
Schenectady N.R. Office	3	9	34370	71519	0.26	0.69
TOTAL DOE AND CONTRACTOR	264	425	4561717	4356794	0.83	1.00

---

(1) DOE statistics prior to July 1981 included occurrences with $100 or more damages.

(2) Annual average.

TABLE VIII

DOE GOVERNMENT MOTOR VEHICLE LOSS
1981 THROUGH 4TH QUARTER

FIELD ORGANIZATION	NO. OF GOVERNMENT VEHICLES	NUMBER OF ACCIDENTS > $250(1) 1981	NUMBER OF ACCIDENTS > $250(1) 1976-80(2)	ACCIDENTS PER MVM 1981	ACCIDENTS PER MVM 1976-80(2)	GOVERNMENT DOLLAR LOSS 1981	GOVERNMENT DOLLAR LOSS 1976-80(2)	DOLLAR LOSS PER 1000 MILES 1981	DOLLAR LOSS PER 1000 MILES 1976-80(2)
Albuquerque Operations	188	6	13	1.0	3.0	8054	32377	1.39	7.25
Chicago Operations	14	1	0	7.3	2.1	2401	36	17.58	0.38
D.O.E. Headquarters	86	21	18	30.8	18.5	14580	5325	21.41	5.36
Energy Technology Centers	86	3	5	7.1	10.6	3475	3677	8.20	7.82
Idaho Operations	60	4	2	3.1	2.1	2773	1175	2.12	1.25
Nevada Operations	44	0	1	0.0	1.5	0	271	0.00	0.52
Oak Ridge Operations	80	0	2	0.0	3.2	0	1064	0.00	1.43
Petroleum Reserves	29	2	0	9.5	0.0	2700	0	12.81	0.00
Pittsburgh N.R. Office	2	1	0	23.3	0.0	287	0	6.68	0.00
Power Administrations	2407	53	66	3.0	4.6	28467	56649	1.62	3.98
Regional Offices	1	0	2	0.0	3.8	0	530	0.00	1.01
Richland Operations	27	0	1	0.0	4.5	0	361	0.00	1.64
San Francisco Operations	32	0	4	0.0	5.8	0	1473	0.00	2.29
Savannah River Operations	68	1	3	3.3	9.8	300	768	0.99	2.21
Schenectady N.R. Office	1	0	0	0.0	19.3	0	19	0.00	1.87
TOTAL DOE GOVERNMENT	3125	92	96	3.3	4.7	63037	89767	2.25	4.37
TOTAL NSC(1976-80)					11.9				7.55

---

(1) DOE statistics prior to July 1981 included occurrences with $100 or more damages.

(2) Annual average.

TABLE IX

CONTRACTOR MOTOR VEHICLE LOSS
1981 THROUGH 4TH QUARTER

FIELD ORGANIZATION	NO. OF GOVERNMENT VEHICLES	NUMBER OF ACCIDENTS > $250(1)		ACCIDENTS PER MVM		GOVERNMENT DOLLAR LOSS		DOLLAR LOSS PER 1000 MILES	
		1981	1976-80(2)	1981	1976-80(2)	1981	1976-80(2)	1981	1976-80(2)
Albuquerque Operations	2040	65	74	5.0	5.7	46531	27969	3.57	2.17
Chicago Operations	1377	33	71	9.6	16.3	25315	22532	7.38	5.14
D.O.E. Headquarters	0	0	0	0.0	8.8	0	267	0.00	7.03
Energy Technology Centers	3	0	0	0.0	0.0	0	0	0.00	0.00
Idaho Operations	946	25	40	2.6	4.2	29722	23055	3.12	2.44
Nevada Operations	2369	49	43	2.2	2.1	66998	37235	2.98	1.84
Oak Ridge Operations	2756	60	82	4.8	6.3	20074	35480	1.61	2.73
Petroleum Reserves	796	103	97	8.3	21.6	28681	45485	2.31	10.15
Pittsburgh N.R. Office	43	4	8	3.3	9.9	9082	2110	7.55	2.76
Power Administrations	0	0	0	0.0	0.0	0	0	0.00	0.00
Regional Offices	0	0	0	0.0	0.0	0	0	0.00	0.00
Richland Operations	1291	84	80	8.2	7.4	71771	41077	6.99	3.80
San Francisco Operations	1590	75	69	11.2	8.4	65531	30204	9.79	3.68
Savannah River Operations	1045	41	48	3.5	4.4	35229	25317	2.97	2.32
Schenectady N.R. Office	43	1	5	5.2	15.7	1581	2254	8.18	6.57
TOTAL CONTRACTOR	14299	540	533	5.2	5.9	400515	256848	3.87	2.82
TOTAL NSC(1976-80)					11.9				7.55

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(1) DOE statistics prior to July 1981 included occurrences with $100 or more damages.

(2) Annual average.

TABLE X

GOVERNMENT AND CONTRACTOR MOTOR VEHICLE LOSS
1981 THROUGH 4TH QUARTER

FIELD ORGANIZATION	NO. OF GOVERNMENT VEHICLES	NUMBER OF ACCIDENTS > $250(1)		ACCIDENTS PER MVM		GOVERNMENT DOLLAR LOSS		DOLLAR LOSS PER 1000 MILES	
		1981	1976-80(2)	1981	1976-80(2)	1981	1976-80(2)	1981	1976-80(2)
Albuquerque Operations	2228	71	87	3.8	5.0	54585	60346	2.90	3.48
Chicago Operations	1391	34	72	9.5	16.0	27716	22567	7.77	5.04
D.O.E. Headquarters	86	21	19	30.8	18.1	14580	5592	21.41	5.42
Energy Technology Centers	89	3	5	6.8	10.3	3475	3677	7.89	7.57
Idaho Operations	1006	29	42	2.7	4.0	32495	24231	3.00	2.34
Nevada Operations	2413	49	43	2.1	2.1	66998	37505	2.93	1.81
Oak Ridge Operations	2836	60	85	4.6	6.2	20074	36544	1.53	2.66
Petroleum Reserves	825	105	97	8.3	20.5	31381	45485	2.48	9.60
Pittsburgh N.R. Office	45	5	8	4.0	9.8	9369	2110	7.52	2.72
Power Administrations	2407	53	66	3.0	4.6	28467	56649	1.62	3.98
Regional Offices	1	0	2	0.0	3.8	0	530	0.00	1.01
Richland Operations	1318	84	81	8.1	7.4	71771	41438	6.91	3.76
San Francisco Operations	1622	75	73	10.7	8.2	65531	31677	9.32	3.58
Savannah River Operations	1113	42	52	3.5	4.6	35529	26085	2.92	2.32
Schenectady N.R. Office	44	1	6	5.0	15.8	1581	2274	7.85	6.43
TOTAL DOE	17424	632	629	4.8	5.6	463552	346614	3.52	3.10
TOTAL NSC(1976-80)					11.9				7.55

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(1) DOE statistics prior to July 1981 included occurrences with $100 or more damages.

(2) Annual average.

TABLE XI

DOE AND CONTRACTOR AIRCRAFT LOSS
1981 THROUGH 4TH QUARTER

REPORTING OPERATION		WING TYPE	NUMBER OF AIRCRAFT	HOURS USAGE	TOTAL ACCIDENTS		FATAL ACCIDENTS		GOVERNMENT DOLLAR LOSS	
					NO.	RATE(1)	NO.	RATE(1)	DOLLARS	RATE(1)
Bonneville Power Adm.	PA	fixed	2	1121	1	89.21	1	89.21	751410	67030330.06
Bonneville Power Adm.	PA	rotor	6	4656	0	0.00	0	0.00	0	0.00
Brookhaven Nat'l lab	CH	fixed	1	131	0	0.00	0	0.00	0	0.00
EG&G - Nevada	NV	fixed	4	630	0	0.00	0	0.00	0	0.00
EG&G - Nevada	NV	rotor	4	1178	1	84.89	0	0.00	150000	12733446.52
Holmes & Narver Subs	NV	fixed	1	169	0	0.00	0	0.00	0	0.00
Ross Aviation, Inc.	AL	fixed	10	7650	0	0.00	0	0.00	0	0.00
Univ. of Calif.(LLNL)	SF	fixed	3	1069	0	0.00	0	0.00	0	0.00
Western Area Power Ad.	PA	rotor	5	3415	0	0.00	0	0.00	0	0.00
TOTAL DOE AND CONTRACTOR			36	20019	2	9.99	1	6.64	901410	4502772.37
TOTAL U.S. GENERAL AVIATION(2)						9.20		1.64		
TOTAL U.S. AIR CARRIER(2)						0.26		0.03		

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(1) Rates are per 100,000 hours.

(2) National Transportation Safety Board - Annual report to Congress - 1980 aircraft data.

AIRCRAFT ACCIDENT DESCRIPTIONS

January 7, 1981 - A twin engine Aero Commander airplane crashed on a landing approach at Burns, Oregon resulting in 3 fatalities and a $751,410 loss.

January 9, 1981 - A Hughes H-500 helicopter crashed at Sky Harbor, Nevada with only minor injuries to the pilot and a $150,000 loss.

October 4, 1981 - A privately owned Cessna TR-182, while on official DOE business, crashed during bad weather near La Sal, Utah resulting in 1 fatality. (not included in the above statistics)

TABLE XII

DOE AND CONTRACTOR LOSS DATA FOR MARINE, RAILROAD, AND MATERIAL HANDLING EQUIPMENT 1981 THROUGH 4TH QUARTER

MARINE LOSS

REPORTING OPERATION		NUMBER OF CONVEYANCES	NUMBER OF ACCIDENTS	HOURS USAGE	ACCIDENTS PER 100 HOURS	GOVERNMENT DOLLAR LOSS	DOLLAR LOSS PER 100 HOURS
Argonne National Lab	CH	7	0	629	0.0	0	0.00
Brookhaven National Lab	CH	2	0	22	0.0	0	0.00
CEER, Puerto Rico	OR	1	0	653	0.0	0	0.00
Rockwell Hanford Oper.	RL	1	0	70	0.0	0	0.00
Univ. of California (LLNL)	SF	3	0	360	0.0	0	0.00
Univ. of Georgia Ecol. Lab	SR	20	0	2250	0.0	0	0.00
TOTAL MARINE		34	0	3984	0.0	0	0.00

RAILROAD LOSS

REPORTING OPERATION		NUMBER OF CONVEYANCES	NUMBER OF ACCIDENTS	MILES USAGE	ACCIDENTS PER 1000 MILES	GOVERNMENT DOLLAR LOSS	DOLLAR LOSS PER 1000 MILES
Albuquerque Transp. Div.	AL	2	0	42216	0.0	0	0.00
EG&G Idaho, Inc.	ID	1	0	1530	0.0	0	0.00
Mason & Hanger	AL	2	2	14717	0.1	1145	77.80
Rockwell Hanford Oper.	RL	106	0	19000	0.0	0	0.00
TOTAL RAILROAD		111	2	77463	0.0	1145	14.78

MATERIAL HANDLING LOSS(1)

REPORTING OPERATION	NUMBER OF ACCIDENTS	HOURS USAGE	ACCIDENTS PER 100 HOURS	GOVERNMENT DOLLAR LOSS	DOLLAR LOSS PER 100 HOURS
D.O.E. Headquarters	0	1245	0.0	0	0.00
Grand Forks E.T.C.	0	2115	0.0	0	0.00
Morgantown E.T.C.	0	1040	0.0	0	0.00
Southwestern Power Adm.	0	2470	0.0	0	0.00
Western Area Power Adm.	0	3292	0.0	0	0.00
TOTAL MATERIAL HANDLING	0	10162	0.0	0	0.00

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(1) Federally operated material handling equipment.

RANKED INJURY DATA

The following supplementary tables of ranked injury data are provided to enable field offices and contractors to make comparisons with others of the same operation type.

The ranking sequence is: death, LWD incidence rate, number of employees.

TABLE S1

INJURY RANKING OF DOE GOVERNMENT UNITS
1981 THROUGH 4TH QUARTER

RANK	GOVERNMENT OFFICE		EQUIV. FULL-TIME EMPLOYEES	T R C		DEATHS	L W C		L W D		1976-1980 INCIDENCE RATE	
				NO.	INCI-DENCE RATE		NO.	INCI-DENCE RATE	NO.	INCI-DENCE RATE	LWC	LWD
1	SPR Proj Management Office	SPR	149	0	0.0	0	0	0.0	0	0.0	1.1	22.0
2	Environmental Meas. Lab	CH	107	0	0.0	0	0	0.0	0	0.0	1.2	8.4
3	Pittsburgh N.R. Office	PNR	84	0	0.0	0	0	0.0	0	0.0	0.5	0.7
4	Pittsburgh Mining Oper.	ETC	78	0	0.0	0	0	0.0	0	0.0	1.2	25.5
5	Amarillo Area Office	AL	58	0	0.0	0	0	0.0	0	0.0	0.8	7.4
6	Schenectady N.R. Office	SNR	57	0	0.0	0	0	0.0	0	0.0	0.3	3.4
7	Rocky Flats Area Office	AL	53	0	0.0	0	0	0.0	0	0.0	0.0	0.0
8	Alaska Power Adm.	PA	42	0	0.0	0	0	0.0	0	0.0	2.3	8.6
9	Southeastern Power Adm.	PA	34	0	0.0	0	0	0.0	0	0.0	0.0	0.0
10	Carbondale Mining Oper.	ETC	25	0	0.0	0	0	0.0	0	0.0	0.0	0.0
11	Dayton Area Office	AL	24	0	0.0	0	0	0.0	0	0.0	0.0	0.0
12	Pinellas Area Office	AL	24	0	0.0	0	0	0.0	0	0.0	0.0	0.0
13	Sandia Area Office	AL	15	0	0.0	0	0	0.0	0	0.0	0.0	0.0
14	NPR Operations Office -Wyo	NPR	12	0	0.0	0	0	0.0	0	0.0	0.0	0.0
15	Savannah River Oper Office	SR	207	2	1.0	0	0	0.0	0	0.0	0.0	0.0
16	Bartlesville E.T.C.	ETC	147	5	3.6	0	0	0.0	0	0.0	0.5	2.5
17	Naval Facilities Eng. Com.	NPR	14	1	7.4	0	1	7.4	0	0.0	4.3	12.8
18	NPR Operations Office - CA	NPR	72	1	1.5	0	1	1.5	1	1.5	0.0	0.0
19	Albuquerque Oper. Office	AL	636	2	0.3	0	1	0.2	10	1.7	1.6	23.6
20	Idaho Operations Office	ID	485	2	0.4	0	2	0.4	8	1.7	0.7	6.3
21	Oak Ridge Oper. Office	OR	1004	8	0.8	0	5	0.5	18	1.9	0.3	19.8
22	San Francisco Oper. Office	SF	337	4	1.2	0	1	0.3	7	2.2	0.8	6.2
23	Nevada Operations Office	NV	245	4	1.7	0	2	0.9	8	3.4	0.8	6.3
24	Pittsburgh E.T.C.	ETC	354	8	2.4	0	1	0.3	13	3.9	0.6	3.7
25	Kansas City Area Office	AL	70	1	1.5	0	1	1.5	3	4.5	0.8	5.9
26	Grand Forks E.T.C.	ETC	77	1	1.4	0	1	1.4	4	5.4	1.4	51.0
27	D.O.E. Headquarters	HQ	7740	64	0.9	0	50	0.7	540	7.3	0.5	6.2
28	S. R. Forest Station	SR	39	4	10.8	0	1	2.7	3	8.1	3.7	31.3
29	Richland Operations Office	RL	336	3	0.9	0	3	0.9	31	9.7	0.3	10.4
30	Region VII - Kansas City		164	2	2.6	0	1	1.3	8	10.3	0.7	3.5
31	Western Area Power Adm.	PA	1547	37	2.5	0	12	0.8	169	11.5	1.8	38.3
32	Morgantown E.T.C.	ETC	252	5	2.1	0	4	1.7	41	17.1	0.6	8.9
33	Chicago Operations Office	CH	435	10	2.4	0	4	1.0	73	17.7	0.2	2.3
34	Albuquerque Transp. Div.	AL	495	25	5.3	0	23	4.9	291	61.9	0.0	0.0
35	Los Alamos Area Office	AL	381	13	3.6	0	12	3.3	243	67.2	4.1	38.0
36	Laramie E.T.C.	ETC	158	2	1.3	0	1	0.7	171	113.6	0.4	2.4
37	Southwestern Power Adm.	PA	217	25	12.1	0	15	7.3	403	195.2	2.6	75.0
38	Bonneville Power Adm.	PA	3399	101	3.1	3	73	2.3	1428	44.2	2.6	48.8
TOTAL DOE GOVERNMENT			19573	330	1.8	3	215	1.2	3473	18.8	1.0	16.5

TABLE S2

INJURY RANKING OF PRODUCTION CONTRACTORS
1981 THROUGH 4TH QUARTER

				T R C			L W C		L W D		1976-1980 INCIDENCE RATE	
RANK	CONTRACTOR		EQUIV. FULL-TIME EMPLOYEES	NO.	INCI-DENCE RATE	DEATHS	NO.	INCI-DENCE RATE	NO.	INCI-DENCE RATE	LWC	LWD
1	G.E. - Pinellas	AL	1760	3	0.2	0	0	0.0	0	0.0	0.1	1.7
2	Fenix & Scisson Subs - Wyo	NPR	85	4	6.6	0	0	0.0	0	0.0	4.4	55.1
3	Bendix Corporation	AL	6678	74	1.2	0	10	0.2	135	2.1	0.2	3.1
4	Exxon Nuclear Idaho Co.	ID	899	11	1.3	0	4	0.5	22	2.6	0.5	8.6
5	Mound Facility	AL	2038	16	0.8	0	4	0.2	101	5.2	0.1	2.1
6	Union Carbide (Y-12)	OR	6476	53	0.9	0	10	0.2	322	5.2	0.2	4.1
7	Union Carbide (ORGDP)	OR	5380	49	1.0	0	13	0.3	265	5.2	0.5	17.1
8	Union Carbide (Paducah)	OR	1684	19	1.2	0	7	0.4	86	5.4	0.7	24.1
9	Du Pont - Production	SR	5569	27	0.5	0	3	0.1	338	6.4	0.1	6.1
10	Rockwell International	AL	4069	70	1.8	0	24	0.6	338	8.7	0.5	11.0
11	Rockwell Hanford Oper.	RL	3960	118	3.1	0	28	0.7	379	10.1	0.6	23.9
12	United Nuclear Industries	RL	1196	55	4.8	0	8	0.7	116	10.2	1.0	25.4
13	Goodyear Atomic Corp.	OR	3064	42	1.4	0	16	0.5	419	14.4	0.6	22.7
14	Mason & Hanger	AL	2133	27	1.3	0	12	0.6	350	17.3	1.1	11.4
15	Fenix & Scisson - Wyo.	NPR	183	13	7.5	0	6	3.4	41	23.5	9.7	140.7
16	Williams Brothers - CA	NPR	658	18	2.9	0	15	2.4	187	29.9	9.4	43.3
17	Natl. Lead Co. of Ohio	OR	588	11	2.0	0	4	0.7	256	45.9	1.2	15.8
TOTAL PRODUCTION CONTRACTORS			46420	610	1.4	0	164	0.4	3355	7.6	0.4	11.6

TABLE S3

INJURY RANKING OF RESEARCH CONTRACTORS
1981 THROUGH 4TH QUARTER

RANK	CONTRACTOR		EQUIV. FULL-TIME EMPLOYEES	T R C NO.	T R C INCI-DENCE RATE	DEATHS	L W C NO.	L W C INCI-DENCE RATE	L W D NO.	L W D INCI-DENCE RATE	1976-1980 INCIDENCE RATE LWC	1976-1980 INCIDENCE RATE LWD
1	EG&G - San Ramon	NV	192	0	0.0	0	0	0.0	0	0.0	0.7	15.3
2	GE-KAPL - Windsor	SNR	151	0	0.0	0	0	0.0	0	0.0	0.6	13.3
3	EG&G Idaho Subcontractors	ID	23	0	0.0	0	0	0.0	0	0.0	0.0	0.0
4	John A. Blume	NV	21	0	0.0	0	0	0.0	0	0.0	1.5	1.5
5	Du Pont - Research	SR	1099	2	0.2	0	0	0.0	0	0.0	0.0	1.2
6	Univ. Georgia Ecol. Lab	SR	93	5	5.7	0	0	0.0	0	0.0	0.5	3.9
7	GE-KAPL - Knolls	SNR	2398	6	0.3	0	2	0.1	9	0.4	0.4	4.7
8	Oak Ridge Assoc. Univ.	OR	441	15	3.6	0	1	0.2	2	0.5	0.6	10.2
9	Solar Energy Res. Inst.	CH	748	9	1.3	0	1	0.1	10	1.4	0.7	5.9
10	Mtn. States Energy Inc.	ID	164	6	3.8	0	2	1.3	3	1.9	0.4	2.5
11	MATSCO / G.E.	ETC	44	3	7.1	0	1	2.4	1	2.4	3.1	50.5
12	Miscellaneous Contracts	CH	202	4	2.1	0	2	1.0	5	2.6	0.0	0.0
13	Union Carbide (ORNL)	OR	4532	41	1.0	0	13	0.3	155	3.6	0.5	10.7
14	Westinghouse Elec. (NRF)	PNR	970	6	0.7	0	4	0.4	37	4.0	0.5	5.4
15	Hanford Eng. Dev. Lab.	RL	2662	28	1.1	0	11	0.4	111	4.4	0.4	4.7
16	Stanford Linear Acc. Cent.	SF	1507	27	1.9	0	17	1.2	67	4.7	1.7	12.0
17	CEER, Puerto Rico	OR	86	1	1.2	0	1	1.2	4	4.9	0.3	8.0
18	Battelle Memorial Inst.	RL	1310	21	1.7	0	8	0.6	64	5.1	0.9	13.2
19	Boeing Services Int'l.	ETC	39	2	5.4	0	1	2.7	2	5.4	0.0	0.0
20	Sandia National Labs.	AL	7402	84	1.2	0	51	0.7	399	5.7	0.8	8.7
21	Westinghouse Elec. (BAPL)	PNR	2792	21	0.8	0	3	0.1	170	6.4	0.6	10.5
22	Grand Forks E.T.C. Subs	ETC	79	8	10.7	0	3	4.0	5	6.7	0.8	26.7
23	EG&G Idaho, Inc.	ID	3812	59	1.6	0	33	0.9	245	6.8	1.3	17.9
24	Univ. of Calif. (LANL)	AL	7949	116	1.5	0	62	0.8	599	7.9	1.0	11.9
25	EG&G - Santa Barbara	NV	127	4	3.3	0	1	0.8	10	8.3	0.8	1.7
26	Iowa State Univ., Ames	CH	510	14	2.9	0	5	1.0	45	9.3	0.6	7.5
27	Airesearch	OR	578	4	0.7	0	3	0.5	59	10.7	1.0	18.9
28	GE-KAPL - Kesselring	SNR	631	6	1.0	0	4	0.7	82	13.7	2.0	35.6
29	Fermilab	CH	2138	58	2.9	0	28	1.4	300	14.8	1.9	38.8
30	Argonne Natl. Lab (E&W)	CH	4641	100	2.3	0	60	1.4	660	15.0	0.9	10.9
31	Brookhaven National Lab	CH	3843	73	2.0	0	68	1.9	573	15.7	2.4	23.7
32	Univ. of Calif. (LBL)	SF	2845	44	1.6	0	29	1.1	477	17.7	1.6	28.2
33	Energy Systems Group	SF	354	11	3.3	0	7	2.1	62	18.4	0.8	19.0
34	Princeton Univ. (PPPL)	CH	1324	64	5.1	0	35	2.8	360	28.6	2.0	17.3
35	Lovelace Foundation	AL	245	11	4.7	0	5	2.1	77	33.1	3.7	39.4
36	Duquesne Light Co.	PNR	240	3	1.3	0	2	0.9	87	38.2	3.2	43.5
37	Comparative Animal Res.	OR	101	2	4.2	0	1	2.1	21	43.8	2.3	12.5
38	EG&G WASC, Inc. Morgantown	ETC	120	3	2.6	0	3	2.6	75	65.7	0.0	0.0
39	Univ. of Calif. (LLL NV)	SF	92	10	11.4	1	0	0.0	0	0.0	1.6	26.0
40	Univ. of Calif. (LLL)	SF	6977	156	2.4	1	68	1.0	838	12.6	1.4	18.4
TOTAL	RESEARCH CONTRACTORS		63482	1027	1.7	2	535	0.8	5614	9.3	1.1	14.4

TABLE S4

INJURY RANKING OF SERVICE CONTRACTORS
1981 THROUGH 4TH QUARTER

RANK	CONTRACTOR		EQUIV. FULL-TIME EMPLOYEES	T R C NO.	T R C INCI-DENCE RATE	DEATHS	L W C NO.	L W C INCI-DENCE RATE	L W D NO.	L W D INCI-DENCE RATE	1976-1980 INCIDENCE RATE LWC	1976-1980 INCIDENCE RATE LWD
1	LLL Subcontractors	SF	437	0	0.0	0	0	0.0	0	0.0	1.2	27.9
2	Industrial Building Maint.	SR	128	0	0.0	0	0	0.0	0	0.0	0.0	0.0
3	Hanford Env. Health Found.	RL	107	0	0.0	0	0	0.0	0	0.0	0.2	0.2
4	Williams/Fenix & Scisson	SPR	42	0	0.0	0	0	0.0	0	0.0	0.0	0.0
5	Rockwell Subcontractors	AL	32	0	0.0	0	0	0.0	0	0.0	6.2	211.2
6	W. E. (NRF) Subs	PNR	32	0	0.0	0	0	0.0	0	0.0	1.5	7.5
7	EG&G Idaho Subcontractors	ID	22	0	0.0	0	0	0.0	0	0.0	3.2	9.6
8	Brookhaven National Lab	CH	20	0	0.0	0	0	0.0	0	0.0	0.0	0.0
9	Services Inc.	SR	19	0	0.0	0	0	0.0	0	0.0	0.0	0.0
10	San Francisco Office Subs	SF	13	0	0.0	0	0	0.0	0	0.0	0.0	0.0
11	Goodyear Atomic Subs	OR	11	0	0.0	0	0	0.0	0	0.0	0.0	0.0
12	Paducah Subcontractors	OR	10	0	0.0	0	0	0.0	0	0.0	0.0	0.0
13	Nye County Sheriff	NV	9	0	0.0	0	0	0.0	0	0.0	0.0	0.0
14	Southern Bell Tel. & Tel.	SR	8	0	0.0	0	0	0.0	0	0.0	0.0	0.0
15	Mound Facility Subs	AL	7	0	0.0	0	0	0.0	0	0.0	0.0	0.0
16	G.E. - Pinellas Subs	AL	4	0	0.0	0	0	0.0	0	0.0	1.9	223.2
17	Holmes & Narver Subs	NV	1	0	0.0	0	0	0.0	0	0.0	0.0	0.0
18	Calculon Incorporated	HQ	216	2	1.0	0	0	0.0	0	0.0	0.1	0.2
19	Computer Sciences	NV	50	2	4.2	0	0	0.0	0	0.0	1.3	10.2
20	Bendix Field Eng. Corp.	ID	461	5	1.1	0	2	0.5	3	0.7	0.0	0.0
21	Pittsburgh E.T.C. Subs	ETC	72	4	5.9	0	1	1.5	1	1.5	0.0	0.0
22	Fermilab	CH	68	1	1.5	0	1	1.5	2	3.1	0.2	0.2
23	Boeing Computer Services	RL	310	4	1.4	0	2	0.7	13	4.4	0.4	7.6
24	Morgantown E.T.C. Subs	ETC	43	1	5.0	0	1	5.0	1	5.0	0.0	0.0
25	EG&G - Los Alamos	NV	139	5	3.8	0	2	1.5	11	8.4	1.6	12.7
26	Stanford Linear Acc. Cent.	SF	130	4	3.2	0	2	1.6	14	11.4	3.2	39.4
27	Wackenhut Services	NV	295	13	4.6	0	3	1.1	40	14.3	1.1	21.1
28	Zia Co.	AL	1477	19	1.4	0	19	1.4	221	15.7	1.9	31.4
29	LANL Subcontractors	AL	163	9	5.8	0	4	2.6	25	16.1	0.9	3.1
30	Westinghouse Electric	NV	49	1	2.2	0	1	2.2	8	17.3	2.8	30.1
31	GE-KAPL - Knolls Subs	SNR	16	1	6.5	0	1	6.5	3	19.6	1.9	44.9
32	Ross Aviation Inc.	AL	127	7	5.8	0	7	5.8	32	26.4	5.8	56.8
33	S. R. Timber Cutters	SR	59	1	1.8	0	1	1.8	15	26.8	3.6	67.5
34	GE-KAPL - Kesselring Subs	SNR	11	1	9.3	0	1	9.3	3	27.8	6.0	46.7
35	Du Pont - Production Subs	SR	43	1	2.5	0	1	2.5	13	32.0	2.6	16.8
36	EG&G - Nevada	NV	1173	59	5.3	0	35	3.1	375	33.6	2.8	36.5
37	Sandia Lab Subs	AL	158	2	1.3	0	2	1.3	54	35.9	2.0	26.5
38	Dravo Utility Constructors	SPR	533	53	10.5	0	22	4.3	270	53.4	3.3	84.5
39	EG&G - Kirtland	NV	168	7	4.4	0	5	3.1	112	70.0	0.8	2.9
40	DUCI Subcontractors	SPR	195	8	8.7	0	5	5.4	65	70.3	3.0	221.3
41	REECO Subcontractors	NV	233	22	9.9	0	6	2.7	187	84.6	0.5	2.4
42	Fenix & Scisson Subs	NV	36	3	8.7	0	2	5.8	47	136.0	1.9	19.8
43	W. E. (BAPL) Subs	PNR	34	1	3.1	0	1	3.1	48	149.6	3.4	18.0
44	GE-KAPL - Windsor Subs	SNR	18	1	5.9	0	1	5.9	30	178.3	1.6	1.6
TOTAL	SERVICE CONTRACTORS		7179	237	3.6	0	128	1.9	1593	23.9	1.9	28.8

TABLE S5

INJURY RANKING OF COST CONSTRUCTION CONTRACTORS
1981 THROUGH 4TH QUARTER

				T R C			L W C		L W D		1976-1980 INCIDENCE RATE	
RANK	CONTRACTOR		EQUIV. FULL-TIME EMPLOYEES	NO.	INCI-DENCE RATE	DEATHS	NO.	INCI-DENCE RATE	NO.	INCI-DENCE RATE	LWC	LWD
1	Zia Co.	AL	44	0	0.0		0	0.0	0	0.0	2.0	36.7
2	W. E. (NRF) Subs	PNR	217	1	0.5	0	0	0.0	0	0.0	0.0	0.0
3	Parsons/Gilbane	SPR	151	1	0.7	0	0	0.0	0	0.0	1.1	96.0
4	Morrison/Knudsen	ID	108	1	1.0	0	0	0.0	0	0.0	2.4	30.1
5	Rust Engineering Co.	OR	863	26	3.2	0	0	0.0	0	0.0	1.8	49.3
6	Holmes & Narver - Pacific	NV	342	2	0.6	0	2	0.6	17	5.2	0.8	5.2
7	J.A. Jones Const. Co.	RL	937	62	7.0	0	2	0.2	82	9.2	1.2	16.6
8	Brookhaven National Lab	CH	151	4	2.8	0	4	2.8	14	9.8	0.0	0.0
9	Du Pont - Construction	SR	1997	71	3.7	0	17	0.9	212	11.2	1.3	23.6
10	Catalytic Inc.	ID	126	2	1.7	0	1	0.8	42	35.1	1.7	2.9
11	Fermilab	CH	67	6	9.4	0	3	4.7	23	35.9	1.1	54.7
12	Rocky Flats Office Subs	AL	125	4	3.4	0	1	0.8	90	75.8	4.2	60.7
13	Kaiser Engineers	ID	58	5	36.1	0	1	7.2	11	79.4	4.3	96.9
14	REECO	NV	4116	367	9.4	1	206	5.3	3254	83.2	5.3	101.3
TOTAL COST CONSTRUCTION CONTRACTORS			9302	552	6.3	1	237	2.7	3745	42.6	3.0	57.5

TABLE S6

INJURY RANKING OF LUMP CONSTRUCTION CONTRACTORS
1981 THROUGH 4TH QUARTER

RANK	CONTRACTOR		EQUIV. FULL-TIME EMPLOYEES	T R C		DEATHS	L W C		L W D		1976-1980 INCIDENCE RATE	
				NO.	INCI-DENCE RATE		NO.	INCI-DENCE RATE	NO.	INCI-DENCE RATE	LWC	LWD
1	Paducah Subcontractors	OR	66	0	0.0	0	0	0.0	0	0.0	1.3	46.2
2	Goodyear Atomic Subs	OR	69	0	0.0	0	0	0.0	0	0.0	0.9	28.8
3	Brookhaven National Lab	CH	54	0	0.0	0	0	0.0	0	0.0	0.7	6.4
4	W. E. (NRF) Subs	PNR	53	0	0.0	0	0	0.0	0	0.0	2.4	80.1
5	Mound Facility Subs	AL	38	0	0.0	0	0	0.0	0	0.0	0.0	0.0
6	ORGDP Subcontractors	OR	30	0	0.0	0	0	0.0	0	0.0	1.2	12.8
7	W. E. (BAPL) Subs	PNR	21	0	0.0	0	0	0.0	0	0.0	8.4	866.6
8	Stanford Linear Acc. Cent.	SF	20	0	0.0	0	0	0.0	0	0.0	9.3	135.1
9	Amarillo Office Subs	AL	14	0	0.0	0	0	0.0	0	0.0	7.3	81.0
10	Y-12 Subcontractors	OR	14	0	0.0	0	0	0.0	0	0.0	0.0	0.0
11	Dayton Office Subs	AL	12	0	0.0	0	0	0.0	0	0.0	0.0	0.0
12	GE-KAPL - Knolls Subs	SNR	10	0	0.0	0	0	0.0	0	0.0	0.0	0.0
13	Pittsburgh E.T.C. Subs	ETC	8	0	0.0	0	0	0.0	0	0.0	2.8	63.4
14	Natl. Lead of Ohio Subs	OR	6	0	0.0	0	0	0.0	0	0.0	0.0	0.0
15	ORNL Subcontractors	OR	6	0	0.0	0	0	0.0	0	0.0	0.0	0.0
16	GE-KAPL - Windsor Subs	SNR	2	0	0.0	0	0	0.0	0	0.0	8.5	136.7
17	Idaho Office Subs	ID	1	0	0.0	0	0	0.0	0	0.0	5.6	52.3
18	Morrison/Knudsen	ID	75	1	1.4	0	0	0.0	0	0.0	4.0	36.8
19	G.E. - Pinellas Subs	AL	17	3	18.5	0	0	0.0	0	0.0	0.0	0.0
20	EG&G Idaho Subcontractors	ID	25	5	20.9	0	2	8.4	0	0.0	7.9	92.2
21	Thacker Construction Subs	SPR	79	31	41.2	0	0	0.0	0	0.0	0.0	0.0
22	LLL Subcontractors	SF	178	1	0.6	0	1	0.6	4	2.4	1.9	72.7
23	Kansas City Office Subs	AL	33	2	6.4	0	1	3.2	1	3.2	9.9	193.0
24	J.A. Jones Const. Co.	RL	307	22	7.5	0	3	1.0	19	6.5	1.6	31.1
25	Parsons/Gilbane Subs	SPR	229	17	7.8	0	8	3.7	37	17.0	5.0	42.7
26	Chicago Office Subs	CH	162	7	4.6	0	4	2.6	29	18.9	0.0	0.0
27	Bendix Subcontractors	AL	21	1	5.1	0	1	5.1	5	25.4	0.0	0.0
28	Thacker Construction	SPR	227	95	44.0	0	8	3.7	66	30.6	3.1	128.7
29	Catalytic Inc.	ID	372	32	9.0	0	14	4.0	121	34.2	11.1	207.8
30	Oak Ridge Office Subs	OR	519	131	26.6	0	17	3.4	195	39.6	3.0	42.7
31	Princeton Univ. (PPPL)	CH	72	12	17.4	0	4	5.8	34	49.4	5.3	50.1
32	GE-KAPL - Kesselring Subs	SNR	15	1	7.0	0	1	7.0	10	70.0	3.4	90.6
33	Naval Facilities Eng. Com.	NPR	159	13	8.6	0	9	5.9	110	72.6	5.4	13.8
34	Western Area Power Subs	PA	206	5	2.6	0	5	2.6	151	77.1	0.0	0.0
35	Energy Systems Group	SF	43	13	31.7	0	2	4.9	35	85.5	2.6	46.8
36	Morgantown E.T.C. Subs	ETC	32	4	13.3	0	3	10.0	34	112.9	0.0	0.0
37	San Francisco Office Subs	SF	44	30	71.9	0	8	19.2	58	139.0	12.9	53.2
38	Sandia Office Subs	AL	38	8	22.1	0	6	16.6	53	146.3	2.3	39.1
39	Univ. of Calif. (LBL)	SF	16	2	12.8	0	2	12.8	24	153.3	3.8	166.6
40	Los Alamos Office Subs	AL	57	10	18.5	0	3	5.5	100	184.9	4.1	39.4
41	Rocky Flats Office Subs	AL	72	2	2.9	0	2	2.9	128	187.1	1.8	2.9
42	WF&S Monitored Contracts	SPR	83	1	5.1	0	1	5.1	38	193.6	18.0	441.3
43	Williams Brothers Subs -CA	NPR	764	79	10.9	1	41	5.6	299	41.2	0.0	0.0
TOTAL LUMP CONSTRUCTION CONTRACTORS			4291	528	13.2	1	146	3.6	1551	38.7	3.8	64.9

TABLE S7

INJURY RANKING OF ARCHITECTURAL/ENGINEERING CONTRACTORS
1981 THROUGH 4TH QUARTER

RANK	CONTRACTOR		EQUIV. FULL-TIME EMPLOYEES	T R C		DEATHS	L W C		L W D		1976-1980 INCIDENCE RATE	
				NO.	INCI-DENCE RATE		NO.	INCI-DENCE RATE	NO.	INCI-DENCE RATE	LWC	LWD
1	Kansas City Office Subs	AL	15	0	0.0	0	0	0.0	0	0.0	0.0	0.0
2	Rocky Flats Office Subs	AL	14	0	0.0	0	0	0.0	0	0.0	0.4	1.3
3	Giffels Associates Inc.	CH	12	0	0.0	0	0	0.0	0	0.0	0.0	0.0
4	Idaho Office Subs	ID	35	2	6.0	0	0	0.0	0	0.0	0.0	0.0
5	Vitro Engineering	RL	307	5	1.7	0	2	0.7	7	2.4	0.2	0.5
6	Fenix & Scisson	NV	108	2	1.9	0	1	1.0	9	8.8	1.3	11.5
7	Holmes & Narver	NV	369	11	3.1	0	2	0.6	32	9.1	0.1	5.2
TOTAL ARCH/ENG CONTRACTORS			860	20	2.5	0	5	0.6	48	5.9	0.3	3.4
TOTAL DOE AND CONTRACTOR			151107	3304	2.3	7	1430	1.0	19379	13.5	1.1	17.6

Senator DOMENICI. Thank you very much, Mr. Vaughan. Under your environmental programs, there is some activity called Environmental Control Technology Assessments. As I understand it, the goal or aim of that is to anticipate environmental problems, seeking technology and solutions to those in the developing of energy systems. Am I correct in that?

Mr. VAUGHAN. You are correct, sir, in that the purpose of this office is to assess technology development for the purpose of providing the Secretary and the operations of DOE with information as to technology available for environmental compliance.

We are not an R&D arm. I believe I will be followed by energy research, so we do not conduct environmental or energy research ourselves.

Senator DOMENICI. No. It is an assessment?

Mr. VAUGHAN. Yes.

Senator DOMENICI. Now the budget there in 1982 was $13 million, the request, and I understand the new budget is $3.5 million.

Are you going to end the environmental control technology assessment program?

Mr. VAUGHAN. We are significantly ramping that program down, Senator, for three reasons. First, we have consolidated research activities which you will hear about later, and we have gotten out of that business in my office. Second, as we track the downturning of some of the Department's activities and because we are a support activity, we do not feel that we need the previous level. Third, we have some serious concern as to whether it was an appropriate Government function at previous levels to evaluate and furnish information to the public at large about environmental capabilities and technology.

Previously a large number of publications, were issued, which we are significantly reducing or terminating.

Senator DOMENICI. Well, I assume that you feel as you said in your statement, that these activities can best be performed in the private sector?

Mr. VAUGHAN. Yes, sir.

Senator DOMENICI. Is this a hope or is this something that has happened such that you can rely upon it?

Mr. VAUGHAN. Many of our publications, Senator, I have observed have been published by the private sector, so I think we have evidence of interest in the private sector and that there is a pickup of this activity.

It also seems to me axiomatic that suppliers of equipment will provide the public with information about the technological capabilities of that equipment. So in a sense that is in the nature of a hope, but I think it is a well-founded hope.

Senator DOMENICI. Isn't one of the functions of the environmental control technology assessment program to anticipate environmental problems also, not just seeking technological solutions?

Mr. VAUGHAN. Yes, sir, that advance look anticipating problems, will continue. If you notice, we have not, and did not intend to totally terminate that activity. We do intend to scale it down significantly.

Senator DOMENICI. For instance, for now it looks like we are going to move ahead with synthetic fuels. Almost every assessment of where the country is going to get its energy mix indicates significant synthetic fuels by the turn of the century, and I guess the Synthetic Fuels Corporation is going to push a few of those technologies into the marketplace.

Will we be looking at environmental effects of synthetic fuel technologies? I think one of the big inhibitors is that there is a great deal of public fear of the unknown in terms of the environmental problems that come with huge synthetic fuel facilities. Somebody has to be assessing them in a credible way or we lose the public support because where they don't know something the general tendency is not to proceed. Will we be continuing the environmental assessment?

Mr. VAUGHAN. I think, Senator, we plan to do that level of activity. Again, we are not zeroing out this activity.

Senator DOMENICI. But you will be doing that?

Mr. VAUGHAN. Let me ask Mr. Davies to respond, to go into greater detail.

Mr. DAVIES. Senator, as an example of what the Department is doing, the Great Plains gasification plant was authorized with a loan guarantee from the Department. In the negotiation of the agreement for a Federal loan guarantee, the Department insisted that environmental monitoring requirements well beyond that required to meet Federal and State standards be included. This is for the specific purpose of determining the impact of the synthetic fuels operation, and the private people picking up that project did agree to do that work.

Senator DOMENICI. OK. Let me ask about another environmental issue. The Clean Air Act directs the Environmental Protection Agency to promulgate a health standard for airborne radionucleii. They have not promulgated the standard yet from what we understand. Some of us are concerned that this would have a big effect on the Department of Energy in that that standard will have some extremely important ramifications.

Is the Department of Energy having a significant input into this EPA process?

Mr. VAUGHAN. We have urged the EPA, Senator, to promulgate the applicable standards with some dispatch and have provided them with data and analysis over some period of time. So we are an active participant with the Department, with the Agency, on that subject area.

Senator DOMENICI. Now what you have just indicated is that you have urged them to expedite, but is the Department giving their views on what the standard ought to be? I mean, telling them to get on with it is absolutely urgent, and I agree with you, Mr. Secretary. You have got to push to get it done, but are you giving them information so that the Department's position and knowledge is used by them or is at least in front of them?

Mr. VAUGHAN. I believe we have told them what we thought the standard might be.

Senator DOMENICI. And why?

Mr. VAUGHAN. Yes, sir.

Senator DOMENICI. All right; I think the Department's response to the Three Mile Island accident and its own in-house review has been very good. We had some testimony on that yesterday also.

All I can do is encourage your efforts in the nuclear safety program, but I am concerned that an increased proportion of the funding for nuclear safety under the safety program activity may have an impact on operational safety programs. Occupational safety in the Department of Energy has always been very high and really the Department can hold its head very high in that regard.

Could you comment on that record and explain how the reduction in the operational safety area will not have an adverse effect on performance?

Mr. VAUGHAN. Senator, I will at this point with your permission enter into the record our 1981 performance report on nonnuclear safety performance.

As you have indicated, we are proud of the record in that area of our activity. We are making no significant budget cut that relates to occupational safety and health in the Department's activities. We do not think any employee of the Department or its contractors will be any more exposed in the future than they have been in the past. We would expect the safety record to improve. We believe we are fully supporting that.

Senator DOMENICI. For instance, Mr. Secretary, let's just take a specific—liquefied natural gas. We could be wrong.

Mr. VAUGHAN. That particular program, Senator, the liquefied natural gas, is an area that we have identified as, in our judgment, more appropriately done by the private sector. This is not an area that involves the Department's employees or its contractors' employees because we are not operating LNG facilities.

Senator DOMENICI. But LNG safety is a very serious problem.

Mr. VAUGHAN. Yes, sir, it is a problem. However, we believe the gas industry is the appropriate vehicle for dealing with that problem rather than the Government.

Senator DOMENICI. I wonder if you might for the record tell us what we have done in the past in that area? You don't have to now, and give us a little more information as to how you see the role of the private sector, do that as soon as you can.

Mr. VAUGHAN. I will be glad to furnish you, Senator, with the funding to date, the accomplishments to date, and our plan for offering what has been accomplished, packaging and transferring it to the private sector.

We do have meetings scheduled later this month with the gas industry on that subject.

[The information follows:]

LIQUEFIED GASEOUS FUELS SAFETY RESEARCH PROGRAM

The funding for the LGF Safety Research Program for FY 1976-1982 is as follows:

LGF PROGRAM FUNDING BY FISCAL YEAR

(Millions of Dollars)

	76	77	78	79	80	81	82
Yearly	0.2	1.1	2.1	3.2	6.8	6.4	4.0
Cummulative	0.2	1.3	3.4	6.6	13.4	19.8	23.8

The goal of the program was to obtain sound technical information needed by regulatory agencies, the industry, and the general public in making siting decisions about LGF facilities. This required the acquisition of new information from theoretical studies, laboratory investigations, and confirmatory field experiments. The problem of how the hazard to the public increases with spill size was identified as the most important question, although release prevention and release control were also considered to be significant. To be able to confidently extrapolate results obtained in the DOE program to spills of credible size, DOE chose the strategy of conducting a series of spills of increasing magnitude. Tests of spills of 1 to 40 cubic metres of the liquefied fuel on water were conducted. The results are now being interpreted, and reports will be completed during FY 1982.

Several solid accomplishments have come out of the DOE program. The first adequate array of instruments and the supporting data acquisition systems needed for such experiments were developed and made operational in the field. This instrumentation had the accuracy, response characteristics, and durability to perform under stringent field experiment conditions so as to allow obtaining of quality data. This capability enabled confirming in field tests the laboratory observation that LNG containing a mixture of methane, ethane, and propane (as most commercial LNG does) shows a tendency to evaporate the lighter methane preferentially to the heavier molecular weight constituents ethane and propane. Thermal radiation fluxes have been measured for pool fires approaching a limiting value of about 200 kilowatts per square metre, which is twice the value specified in current regulations. Rapid Phase Transitions (the sudden change of liquid to vapor so as to cause significant overpressures in the surrounding medium) have been observed under a wide range of conditions, including some not predicted by theoretical considerations. In some cases, the overpressure was sufficient to cause structural damage to the test facility. Additionally, a collection of computer models of varying complexity have been assembled and used in interpreting experimental data.

Finally, we have had informal discussions with gas industry organizations regarding our plans to phase out our LNG program. We have outlined the program goal and accomplishments, apprised them of the current status of the work, and noted the expertise and technical resources available through our LGF contractors. As I stated previously, I have scheduled meetings with industry officials to formally provide them this same information.

Senator DOMENICI. Thank you very much. I would assume we will have some written questions from some other Senators. We will submit them to you, Mr. Secretary, and expect your answers as soon as possible.

I have nothing further, and thank you very much.

Mr. VAUGHAN. Thank you, sir.

Senator DOMENICI. Why don't we have all three of the witnesses come to the table at once? Alvin Trivelpiece, Director of the Office of Energy Research in the Department; Dr. Richard L. Schriever, Director of the Office of Inertial Fusion, defense programs, Department of Energy, and Mr. Ralph Caudle, Director of the Office of Safeguards and Security, defense programs, within the Department of Energy—thank you all very much for being here today.

We have your testimony, Mr. Trivelpiece, and it will be made a part of the record. You can proceed as you see fit.

STATEMENT OF HON. ALVIN W. TRIVELPIECE, DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. JAMES LEISS, ASSOCIATE DIRECTOR FOR HIGH ENERGY AND NUCLEAR PHYSICS

Dr. TRIVELPIECE. Thank you, Mr. Chairman. I am here today to discuss the fiscal year 1983 request for two appropriations. One is the general science and research appropriation which is $601 million, and the other is the energy supply R&D appropriation which is $902 million. The general science appropriation includes the high energy and nuclear physics programs which is $560 million, and the life sciences research and nuclear medicine applications program, which is $39 million. The energy supply R&D appropriation, there is includes the basic energy sciences program, and that is $282.9 million; the biological and environmental research program, which is 129.8 million; and the magnetic fusion energy program which is $444.1 million; and a collection of other programs totaling $45.3 million that are described in the prepared testimony that has been submitted for the record.

What I would like to do first is discuss some of the elements of the general science and research appropriation. First is the high energy and nuclear physics program. This is a frontier area of research, and it is concerned with trying to understand the properties of the nuclei of atoms and their constituent parts. It involves quite a few major facilities, and it is one of the ironies I suppose of research that sometimes the largest facilities are needed to study some of the smallest things. You are familiar with the program to some extent, I am sure. The Fermi Laboratory is included in this appropriation, as are the Brookhaven National Laboratory accelerator activity, the Stanford Linear Accelerator Center and the Meson Physics facility at Los Alamos which I am sure you toured many times.

I regard the programs that are included in this appropriation in here I regard as being watershed activities. When looking at the past, there are very few things in our lives today that have not been touched in some respect by activities that have their historical origins in these programs.

The nuclear science research that took place 50 years ago and commenced with the work of Lawrence at the Berkeley Laboratory, has led to the nuclear weapons activities as well as to the entire nuclear industry; has made principal contributions to solid state sciences and various kinds of applications where radiation is used to harden materials; as well as to nuclear medicine which I will talk about in a moment.

The Department of Energy supplies the resources for about 90 percent of this activity in the United States. The National Science Foundation supports the remaining portion of it, and in a sense, the activities that the United States supports are certainly important in the competition of world-class research. We are among the leaders in this area of research.

The life sciences research and nuclear medicine applications program has its origins in the Atomic Energy Commission. In those days, the people who were writing the Atomic Energy Act were concerned that there might be adverse impacts on humans as a result of radiation associated with nuclear activities. That concern has come today to be directed toward how cells are modified as a result of exposure to radiation, and how they repair themselves. There are two elements to this.

One is what are the possible adverse impacts to human beings, and the other is what are the benefits to mankind that might be derived from the use of nuclear energy and nuclear techniques. The chances are one in two that anyone going to a hospital, is going to have applied to them some diagnostic or treatment method that is related to nuclear medicine. I am sure you are familiar with thyroid tests which use radioactive iodine to determine abnormalities of the thyroid gland. That is a $200 million annual industry in the United States, and I am sure that it returns quite a bit more into the Federal treasury than was ever invested in bringing it on line.

You are also familiar with pion cancer therapy. I am sure Dr. Rosen has told you about that. At Los Alamos more recent activity has focused on positron emission tomography which for the first time permits, for example, diagnostic scans of human brains, which enables physicians to identify glucose uptake in a way that permits understanding of such things as dementia, schizophrenia, and other types of brain problems.

Senator DOMENICI. How much time of the year is Mr. Roser's facility going to be able to work this year?

Dr. TRIVELPIECE. I believe he has asked for 21 weeks, although I would like to refer that question to Dr. Jim Leiss who is the head of the high energy and nuclear physics program.

Dr. LEISS. I believe we will be able, with the requested budget, to operate about 2,500 hours in fiscal year 1983. That is somewhat less than in fiscal year 1982.

Senator DOMENICI. How many weeks is that?

Dr. LEISS. I haven't got it in weeks. It might well be 21 weeks.

Senator DOMENICI. Well, has he told you that at that level they can do the minimum type activities that they have to do? Last year we had to put in some extra money, isn't that right?

Dr. LEISS. Yes, sir. Last year there was money provided through the Defense programs as a partial contribution to their use of the facilities. To the best of my understanding, those funds are not being requested in the Defense programs this year. That is the major reason for the reduction in the operations.

Senator **Domenici**. Would you submit for the record what they requested so that we can compare that and what their justification for it was so we can compare it with what we are able to do with the levels requested?

Dr. **Leiss**. We will be pleased to.

[The information follows:

We are very much concerned about low levels of utilization of LAMPF as well as the other national nuclear physics accelerator facilities. Effective operations of these facilities is essential to the conduct of our research work. In setting research priorities, Nuclear Physics assigned highest priority to the internationally unique scientific capabilities of the Clinton P. Anderson Meson Physics Facility (LAMPF), the William H. Bates Electron Linear Acclerator, and the Lawrence Berkeley Laboratory Bevalac. However, within an overall constrained budget, difficult decisions were necessary for even the highest priority programs.

In fiscal year 1982, LAMPF will operate 3,100 beam hours for research. The President's Budget provides for 2,500 beam hours in fiscal year 1983. This reduction is due to two principal factors: Defense Programs provided $2 million for LAMPF accelerator operations in fiscal year 1982; we have no indication at this time that any Defense Program support will be provided toward LAMPF operations in fiscal year 1983. The second factor is the increased electric power rates beyond general inflation. At LAMPF, this 20 percent reduction in research time is greatly magnified in terms of research output because 10 to 12 experiments can simultaneously be conducted.

In its budget request, submitted to the Department in March 1981, Los Alamos National Laboratory requested $34.4 million for LAMPF operations in fiscal year 1983. This requested budget would have permitted LAMPF to operate for 3,500 beam hours on target. For the record, I will provide background information on LAMPF operations.

LAMPF is the world's leading medium energy nuclear physics accelerator facility serving each year approximately 450 scientists from 90 institutions. Of total beam time, 60 to 70 percent annually is provided to university-based scientists who conduct their research at LAMPF. Both we and the Laboratory strongly believe that LAMPF beam hours must be maintained at highs levels so as to match the research needs of the Department and American scientists.

LAMPF OPERATIONS

[B/A in millions]

Source of support	Actual fiscal year 1981	Fiscal year 1982 current estimate	Fiscal year 1983		
			March 1981 LANL budget request to DOE	President's budget	Funding required for maintenance of fiscal year 1982 level of operations
Nuclear physics	$23.5	$25.4	$34.4	$28.5	
Defense programs	0	2.0	0	0	
Total	$23.5	$27.4	$34.4	$28.5	$31.0
Beam hours on target	3,104	3,100	3,500	2,500	3,100

Senator **Domenici**. I am concerned that we have such an enormously expensive facility in place that we don't look at that in terms of the operational cost. Most of it is attributable to energy as you all understand. The energy costs have gone up enormously and without the energy it can't run. If you would do that for the Committee we would appreciate it.

Dr. **Leiss**. We will be pleased to do that, sir. I might comment that this problem of trying to make effective utilization of all of our large facilities in the high energy and nuclear physics program in the face of power increases and in the face of other pressures on the program and budget is a serious problem, and we are trying to cope with it as best we can.

Senator **Domenici**. Thank you very much. Proceed.

Dr. **Trivelpiece**. Thank you, Mr. Chairman. I would like to now proceed with the energy supply R&D appropriation. That includes the basic energy sciences program which is a broad-based collection of activities that form the underlying base of the science and technology that is needed for various areas of the mission-oriented programs which the Department supports.

The basic energy sciences program includes research in physics, chemistry and materials sciences. It is a large collection of research activities that are done in laboratories, universities, and to a lesser extent in private industries. There are many activities, too many to summarize in any practical way, but the program also includes a collection of facilities. I wanted to mention one facility that is managed in this program. That is the National Synchrotron Light Source which is coming into operation at Brookhaven. I think that facility represents a very practical solution to trying to provide major facilities that keep the United States in various forefront areas. The facility will be operated in a mode that is approximately 40-percent utilization by industry, 40 percent by the universities and 20 percent by the scientists at Brookhaven National Laboratory.

It provides a new tool with which to improve the ability to make integrated circuits and things like that, and it is coming on line right now.

The biological and environmental research program is another program that is in the energy supply R&D appropriation. It involves a collection of programs and projects that try to investigate various aspects of energy-related pollutants and what they do to human beings and to the environment. This involves essentially research on toxicity and teratology. Teratology is the situation that describes what happened with thalidomide where a chemical is not harmful to an individual but may be harmful to the offspring of that individual. Mr. Vaughan referred to synfuels and things like that. Let me use that as an example. With the coal liquid that is generated, one might worry about the mutagenisic characteristics of such liquids. In fact, it turns out as a result of research that has been done in this biological and environmental research program, of the thousands of compounds that are contained in coal liquid it has been demonstrated that only a very few are in fact mutagenic, and that those can be, by process control, eliminated from the product stream. So this type of research is very cost effective in that it doesn't require the development of a subsequent mitigation strategy but in fact allows the strategies, that prevent the problem from occurring to be developed concomitantly with the technology, so these harmful compounds can be designed out before a hazard appears.

The final program in this category I want to discuss, is the magnetic fusion energy program. This is a mission-oriented activity, and it seeks primarily to demonstrate that you can have net energy release from fusion, the process that goes on in the sun. Once that demonstration has taken place, then it is necessary to develop the technology base that will convert that scientific achievement into a practical energy delivery system.

Over the years, the progress in this program has been very systematic and steady, and we are now, I think, within striking distance of making some key demonstrations that are needed. If the many facilities and many laboratories involved in this program, I am only going to mention the Tokamak fusion test reactor (TFTR) at Princeton. TFTR is scheduled to come into operation this December. The experiments which will demonstrate net energy release from a fusion plasma are scheduled to take place in 1985.

The other principal magnetic fusion project involves another scheme for containing the high temperature plasma. This concept is being developed at Lawrence Livermore Laboratory and is called the fusion test facility [MFTF-B]. MFTF-B was scheduled to come into operation in 1986. Certainly one of the potential uses of fusion is to generate electricity. However, it is my conviction that at some stage when the program has demonstrated an ability to produce neutrons in a copious quantity, there will be other practical uses for neutrons. Thus there should be some return to the taxpayers based on this investment long before it will be possible to generate useful quantities of electricity.

In summary, what I wanted to comment on is the fact that we are certainly in difficult economic times. There is need to control the budget in a practical sense, and I have heard you make remarks on that at a recent dinner that we both attended.

The other side of that is the need to maintain a balanced R&D program that helps the United States in its ability to make an economic recovery that is practical because without that kind of R&D, we won't be able to have an effective long-term economic recovery.

The program that I have described and the activities contained within it reflect an attempt to balance between those two requirements; this is the need to control the budget and the need to maintain the United States as the leader in these various areas of R&D.

That completes the remarks I planned to make. I will be glad to answer any questions you might have.

[The prepared statement of Dr. Trivelpiece follows:]

Statement of Alvin W. Trivelpiece
Director
Office of Energy Research
Department of Energy
Senate Energy and Natural Resources Committee
Subcommittee on Energy Research and Development
March 19, 1982

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today to discuss the FY 1983 budget request for the research programs supported by the Office of Energy Research. The programs included under the General Sciences and Research appropriation are High Energy Physics, Nuclear Physics and Life Sciences and Nuclear Medicine Applications. Included in the Energy Supply R&D appropriation are Basic Energy Sciences, Biological and Environmental Research, Magnetic Fusion Energy, Energy Research Analyses, University Research Support, and Multiprogram General Purpose Facilities.

The research programs supported by the Office of Energy Research are important investments in our Nation's future. I believe that a vigorous program of scientific research contributes to national security, economic growth and, in no small sense, to human culture and understanding. Our ability to solve our economic and technological problems in this decade and beyond will depend on the scope and depth of our scientific knowledge and on the progress that results from continued support for basic research programs.

Federal support for the scientific programs being discussed today is appropriate not only because of their long-term, high-risk nature but also because that support is essential to many activities that are clearly in the domain of the Federal government, such as space and defense. However, research costs are increasing and the reality of our situation is that we must use our resources intelligently. We will need to be selective, with the emphasis on those projects that are of the highest quality and appropriate relevance.

Let me turn now to the budget request for our programs. The total FY 1983 budget request for the programs supported by the Office of Energy Research is $1.5 billion. Of that amount, $601 million falls under the General Sciences appropriation, with $902.1 million under the Energy Supply R&D appropriation. Table 1 summarizes the Energy Research request. Under General Sciences, the FY 1983 budget request for High Energy Physics is $429.0 million; for Nuclear Physics the request is $131.0 million. Our request for Life Sciences Research and Nuclear Medicine Applications is $39.0 million. Finally, we are requesting $2.0 million for General Sciences Program Direction. Under Energy Supply R&D, our FY 1983 budget request includes $282.9 million for Basic Energy Sciences, $129.8 million for Biological and Environmental Research, $444.1 million for Magnetic Fusion Energy, $2.6 million for Energy Research Analyses, $5.1 million for University Research Support and $34.0 million for Multiprogram General Purpose Facilities. Our request also inlcudes $3.2 million for Advisory and Oversight Program Direction and $0.4 million for Policy and Management.

I would like to discuss each of these programs briefly, beginning with those under the General Sciences appropriation, and then I would be pleased to respond to questions.

Table I

Office of Energy Research
Summary by Program
($ in millions)

	FY 1982 Estimate	FY 1983 Estimate
General Sciences		
High Energy Physics	$364.5	$429.0
Nuclear Physics	133.9	131.0[a]
Life Sciences Research & Nuclear Medicine Applications	47.4	39.0
General Sciences Program Direction	1.9	2.0
Unobligated Balances/FY 1980 and FY 1981 Deferrals	-5.0	0
Subtotal	$542.7	$601.0
Energy Supply - R&D		
Basic Energy Sciences	$243.3	$282.9[b]
Biological and Environmental Research	165.0	129.8
Magnetic Fusion	453.8	444.1
Energy Research Analyses	3.0	2.6
University Research Support	10.6	5.1
Multiprogram General Purpose Facilities	32.6	34.0
Advisory and Oversight Program Direction	3.3	3.2
Policy and Management	1.0	0.4
Subtotal	$912.6	$902.1
Total	$1455.3	$1503.1

a/ Reflects transfer of National Superconducting Cyclotron project to National Science Foundation (NSF); prior to transfer, $6.8 million was planned for the project in FY 1983.

b/ Reflects transfer from NSF of Stanford Synchrotron Radiation Laboratory, resulting in increase of $6.8 million in FY 1983 request.

HIGH ENERGY AND NUCLEAR PHYSICS

The High Energy and Nuclear Physics (HENP) programs are following lines of inquiry that have occupied man's mind throughout history. As a result of continuing research in high energy and nuclear physics, we now know more than ever before about the universe in which we live, the fundamental constituents of matter and the laws of nature that underlie all physical processes. Energy Research programs fund approximately 90% of the nation's research in high energy and nuclear physics, with the remainder supported by the National Science Foundation. These programs have been extremely successful over the last 2-3 decades. HENP-supported researchers have won five Nobel prizes in the last seven years and fifteen in the last 25 years.

During budget hearings every year, there is considerable discussion about the large laboratory and university facilities--accelerators, colliding beam facilities, detectors--that are required to carry out research in high energy and nuclear physics. Today, I would like to focus for a moment on another key term in the High Energy and Nuclear Physics dictionary. That term is "user group." Generally the experimental research in High Energy and Nuclear Physics is done by university-based scientists who frequently collaborate, or form user groups, with scientists from other universities or DOE's national laboratories.

The term user group, while descriptively accurate, does not adequately convey the importance of the concept either in terms of research or the training of tomorrow's scientists. Let me take a moment to elaborate on that concept. The size and complexity of a typical High Energy Physics research experiment makes it especially appropriate for users from a number of institutions to collaborate. These research teams design an experiment at their home institutions, then submit a proposal to a scientific program advisory committee made up of representatives from the labs and university community who evaluate the proposal and assess its relative priority for scarce accelerator time. If approved by the committee and the management of the appropriate lab, the research team fabricates, installs and tests the apparatus at the lab. Laboratory staff, in addition to constructing, operating and carrying out research on the accelerators, also provide significant assistance to the user group at this stage of the process. Experiments are carried out with laboratory assistance, and the recorded data is taken back to the home institutions for analysis and publication. The entire process from conception to publication generally takes from three to five years. Some experiments are also conducted by accelerator laboratory scientists who must compete for accelerator time in the same way as the user groups do.

The High Energy Physics program, focused at three major accelerator laboratories, supports over 100 user groups. The Nuclear Physics program, carried out at eight national facilities, accommodates approximately 70 user groups of university researchers. Through research and planning activities participants from a total of about 100 universities all across the country contribute to the success of the HENP programs. These user groups and the staffs of the laboratories represent the all important human side of these high technology programs.

HIGH ENERGY PHYSICS

Let me turn now to the FY 1983 budget request for the High Energy Physics Program. The FY 1983 budget request for High Energy Physics is $429 million in budget authority. Of that amount, $331 million is for operating expenses; $47.5 million is for capital equipment and $50.5 million is for construction (Table 2). These funds will enable us to continue to seek a better understanding of the basic constituents of matter and the fundamental forces of nature that comprise and control the world around us.

In this century, scientific investigation has focused on ever more fundamental constituents of matter, and on more elemental concepts. The research frontier first moved from molecules to atoms to nuclei to the constituents of nuclei (protons and neutrons). Recently it has moved to even more elemental subnuclear constituents, such as "quarks", "leptons" and "bosons".

To probe into the depths of matter, into the domain of quarks, scientists use intense beams of very energetic particles which can be produced only by high energy particle accelerators. Progress in High Energy Physics is dependent on the availability of these forefront accelerator and colliding

Table 2

High Energy Physics
Budget Authority
($ in Millions)

	FY 1982 Estimate	FY 1983 Estimate
Operating Expenses	$ 269.2	$ 331.0
Capital Equipment	40.7	47.5
Construction	54.6	50.5
Total High Energy Physics	$ 364.5	$ 429.0

beam facilities and complex detectors that map the effects of particle collisions. The smaller the particle to be studied and the higher the energies holding its component parts together, the larger and more powerful must be the accelerators, detectors and other equipment required to do the research.

This technology, however, is only one part of the program. Progress in High Energy Physics research is based on a continuing interplay of advancements in experiment, theory and technology. High Energy Physics experiments are done at the forefront of theoretical and technical knowledge; and the range of experiments possible is determined by the available technology. Physicists frequently have to invent unique equipment to carry out the experiments of greatest importance. It is in this way that High Energy Physics contributes directly and immediately to the technological base of the country.

This technological advancement, while not the goal of the research, is a virtually guaranteed bonus which cannot be predicted in advance. There have been many spin-offs from High Energy Physics research, including the technology of superconducting materials and devices, radio frequency power generation, materials analysis and medical applications, including new methods of treating cancer. More recently, the use of synchrotron light from particle accelerators opened up totally new research capabilities in chemistry, solid state physics, biology and industrial applications. Free-electron lasers, driven by particle accelerators, promise new capabilities for enhanced laser power and control. Radiation processing, which was born from this science, has many exciting new applications ranging from the manufacture of heat-shrinkable electrical insulation to the sterilization of wastes and the preservation of food.

Because of the length of time required to obtain research results and to assess the true significance of these results vis a vis other research results, the specific end product of the research--the new knowledge--cannot readily be planned for or predicted in advance. Despite this, the history of progress and achievement in this field enables us to say confidently that we are moving rather rapidly toward our goal of better understanding the physical world around us.

For example, we have an increasingly better understanding of the so-called basic forces in nature. It appears now that the previously assumed four forces of nature--electromagnetic, weak nuclear and strong nuclear forces, and gravity--may indeed be different forms of a single unified force. Research results have indicated that the weak nuclear and electromagnetic forces are actually a single force--the electroweak force. The 1979 Nobel Prize went to two U. S. physicists for work toward this unification. The 1980 Nobel Prize in Physics also was given to two U. S. physicists for work that, ultimately, may unify the strong nuclear and electroweak forces into a "grand unified force," as it is referred to. This would reduce the number of forces to only two. Current thinking is that the gravitational force will be incorporated into a unification scheme, thus bringing all of the basic forces into a single unified framework, a life-long goal of Albert Einstein. We cannot predict what will follow from research aimed at verifying this unification theory. However, we can anticipate profound, world-changing effects analogous to those that followed the unification of electricity and magnetism by Maxwell in the late 19th century and the unification of matter and energy by Einstein early in this century.

The FY 1983 budget request of $429 million for High Energy Physics compares to $364.5 million in FY 1982. This increase of $64.5 million would permit us to pursue these important lines of investigation with a significantly higher level of utilization of existing facilities. It also would provide for continued progress on the Fermilab development program as well as long-range accelerator R&D. More specifically, it would allow us to increase facility utilization at Fermilab, the Stanford Linear Accelerator Center (SLAC) and at the Brookhaven National Lab (BNL). It would also allow us to provide additional support for university and laboratory groups at levels matched to the higher utilization level of facilities and the greater complexity of experiments.

The high energy particle accelerator and colliding beam facilities that would be operated under the requested FY 1983 budget include the 30 billion electron volt (GeV) proton Alternating Gradient Synchrotron at Brookhaven, the 500-1000 GeV proton synchrotron at Fermilab and the 32 GeV linear electron accelerator at SLAC. SLAC also has two electron-positron colliding beam facilities for which the linear accelerator acts as the injector. These facilities are called SPEAR and the Positron-Electron Project (PEP). Each of the three national accelerator centers provides a unique set of capabilities which complement the others. Together, they represent the facilities essential for a comprehensive national research program in High Energy Physics.

The FY 1983 budget request for operating expenses of $331 million is necessary to increase the low facility utilization levels experienced in recent years as a result of fiscal restraints, rapidly increasing power costs and the construction of new or upgraded accelerators. The FY 1983 request would allow us to increase utilization levels that are currently below 50% to the 60-70% range. Another major feature of the operating program in FY 1983 is the shakedown, initial operation and achievement of the first circulating beam in the Energy Saver modification at Fermilab. Energy-Saver is the first step of an ongoing development program aimed at increasing the power of the proton synchrotron at Fermilab while, at the same time, reducing the cost of electricity required to run accelerators. The Energy-Saver, which consists of a ring of superconducting magnets installed inside the main ring tunnel, will extend operation of the accelerator to 500 GeV or higher for fixed target experiments. It is these superconducting magnets that operate at temperatures of nearly absolute zero that allow major savings in electric power costs.

The operating expenses request also will give priority to operations at PEP, the electron-positron colliding beam facility at SLAC. PEP began operation in late 1980. In FY 1983, the full initial complement of detectors, including the High Resolution Spectrometer and the Time Projection Chamber, will be in operation.

The construction request of $50.5 million includes $36 million for continuation of the Fermilab development program, $18 million each for Tevatron I and II. Tevatron I, will permit acceleration up to 1000 GeV and provide a facility for proton-antiproton collisions at 1000 GeV. Tevatron II will further expand the accelerator's capabilities by providing upgrading of the experimental areas and beam lines tangential to the main ring for fixed target experiments. The remainder of the construction request is for Accelerator Improvement Projects essential to maintain the reliability, efficiency and scientific effectiveness of the existing accelerator facilities and for General Plant Projects essential to the efficient and reliable operation of the laboratory sites.

Budgets for High Energy Physics have fallen short of long-term planning levels in recent years and especially in FY 1982. These shortfalls have been absorbed primarily by substantial reductions in the level of facility operations and by cutbacks in the rate of construction of facilities, especially on the ISABELLE project. No construction funding for the ISABELLE project is requested in FY 1983. Difficulties have been encountered in the development of suitable superconducting magnets for this project. While considerable and encouraging progress has been made during the last year, substantial effort is still needed to develop a prototype capable of being produced at acceptable costs in the number required. The R&D efforts supported at Brookhaven allow for development of suitable magnets and for the analysis of alternate accelerator options which, while retaining unique and exciting physics research potential, can be constructed within available budget resources.

Let me turn now to the Nuclear Physics program.

NUCLEAR PHYSICS

The FY 1983 budget request for Nuclear Physics is $131 million, with $113.4 million of that for operating expenses, $9.9 million for capital equipment and $7.7 million for construction (Table 3). Through the Nuclear Physics program we continue to seek a better understanding of atomic nuclei and nuclear matter at the most fundamental level possible. By using nuclei as a "proving ground" we also hope to learn more about the fundamental forces of nature--a goal Nuclear Physics holds in common with High Energy Physics.

Table 3

Nuclear Physics
Budget Authority
($ in Millions)

	FY 1982 Estimate	FY 1983 Estimate
Operating Expenses	$ 112.4	$ 113.4
Capital Equipment	9.5	9.9
Construction	12.0	7.7
Total Nuclear Physics	$ 133.9	$ 131.0

If we were to achieve these goals completely, we would be able to quantitatively describe all of the diverse structures, properties and interactions of nuclei in terms of the fundamental forces and constituents of our universe. Although we may never completely realize these goals, their pursuit does lead us to a better understanding of nuclei and their role in the physical universe. In doing so, it gives us a national base of knowledge, techniques, instrumentation and skilled manpower in critical technologies.

The FY 1983 budget request would provide for a continuing program of closely related experimental and theoretical investigations of atomic nuclei. Basic nuclear physics research has a growing interaction with high energy particle physics and astrophysics. In FY 1983, these growing interface areas of nuclear physics will be emphasized. As our understanding of quarks grows it is becoming clear that quarks and their interactions must play an important role in the structure, internal dynamics and interactions of nuclei. However, the nature of this role is an open scientific issue. This issue would be explored through theoretical and experimental investigations in FY 1983, investigations that will include a look at the possibility of new and very different forms of nuclear matter.

Nuclear physics, high energy particle physics and astrophysics also share an interest in the weak interaction. One of the fundamental forces of nature, the weak interaction governs the beta decay of nuclei. In FY 1983, research at the Los Alamos Clinton P. Anderson Meson Physics Facility

(LAMPF) and at MIT's William H. Bates Electron Linear Accelerator would focus on experiments which are intended to provide understanding aimed at the unification of the strong, weak and electromagnetic forces of nature. Work is also being done with neutrinos at Brookhaven. Because neutrinos are the only form of radiation that can escape the interior of the sun without many changes, they are our only direct source of information on the physical processes of the sun's interior. In addition to improving our understanding of the unified theories of the fundamental forces, increased knowledge about neutrinos could lead to a better understanding of the origins of our universe.

Also in FY 1983, the high quality beams and detector systems now available at the Holifield Heavy Ion Research Facility at the Oak Ridge National Laboratory will be used to study the mechanisms by which colliding nuclei exchange mass, energy and spin. Completed last year, the Holifield facility will conduct its first full year of research in FY 1982.

The FY 1983 budget request of $131.0 million for Nuclear Physics is a decrease of $2.9 million from the FY 1982 appropriation. That decrease results in part from the transfer of the National Superconducting Cyclotron Laboratory construction project to the National Science Foundation. It was funded at $4.5 million for FY 1982.

As is the case in High Energy Physics, the capabilities of accelerator facilities determine which experiments can be conducted and which cannot. The LAMPF and Bates facilities and the Bevalac at the Lawrence Berkeley Laboratory are unique in the world and serve well their respective areas of basic nuclear research. Efficient operation of these facilities will be given high priority in FY 1983. Because of budgetary constraints, the number and mix of low energy and heavy ion facilities is undergoing reevaluation so that the new and unique capabilities of the Holifield Heavy Ion Research Facility and the Argonne Tandem/Linac Accelerator System (ATLAS), now under construction, can be fully utilized.

The FY 1983 construction request of $7.7 million for Nuclear Physics includes $3.7 million to complete construction of ATLAS. This new facility will provide heavy ion beams of exceptional quality in a previously unexplored energy range. To accommodate this evolution and assure a balanced and productive program within the FY 1983 budget, research of lesser priority at several other facilities will be reduced or possibly phased out.

Mr. Chairman, I would now like to focus on the Life Sciences Research and Nuclear Medicine Applications program which is carried out by our Office of Health and Environmental Research.

LIFE SCIENCES AND NUCLEAR MEDICINE APPLICATIONS

The Life Sciences and Nuclear Medicine Applications program, with an FY 1983 budget request of $39.0 million, consists of two major independent research efforts (Table 4).

Table 4

Life Sciences Research and Nuclear Medicine Application Budget Authority
($ in Millions)

	FY 1982 Estimate	FY 1983 Estimate
General Life Sciences	$26.4	$18.8
Nuclear Medicine Applications	19.0	18.5
Sub-Total Operating Expenses	45.4	37.3
Capital Equipment	2.0	1.7
TOTAL	$47.4	$39.0

The General Life Sciences program, for which $18.8 million is requested, develops basic knowledge on the structures and functions of normal biological systems. The information developed in this program supports applied research carried out by the Biological and Environmental Research (BER) program of our Office of Health and Environmental Research. The goal of the BER program, which is discussed later in my testimony, is to determine the health and environmental effects of pollutants from energy technology development and use. In order to understand these health effects, we must know more about how human biological systems operate under normal conditions.

With this goal in mind, the General Life Sciences program supports long-term basic research in biophysics, genetics, cell biology, chemical physics and instrumentation. Research in each of these areas contributes to our understanding of the complex biological molecules and other components of cells and living systems. More specifically, we are trying to learn more about how molecules, cells and subcellular structures are damaged temporarily or permanently by pollutants, and what internal mechanisms exist to repair that damage.

In addition to improving our understanding of normal biological processes and their response to energy-related pollutants, the General Life Sciences program has also developed a wide range of commercially useful biomedical instruments used in vaccine production, clinical testing, and cell separation and analysis. More recent advances include ongoing efforts to develop techniques to identify the body's proteins or gene products. If successful, this would allow early detection of abnormal genetic changes and disease states. Recent genetic research on bacterial cells has led to development of the universally used Ames Assay for rapid screening of potentially cancer- or mutation-causing agents.

While the equipment required to carry out this research is many times smaller and less expensive than the accelerators used for High Energy and Nuclear Physics research, these long-term science programs all look to advances in equipment to allow research into previously unexplored areas. The General Life Sciences program supports research in instrumentation sciences to increase our ability to identify and measure rare biological changes. The recently developed fast flow cytometer is one example of new and improved instrumentation that serves as powerful tools to help us understand the effects of pollutants on living systems. With this automated instrument we can now scan hundreds of thousands of living cells in a few minutes, to identify abnormal cell structures or numbers of chromosomes as well as mutant cells.

In FY 1983 the General Life Sciences program will continue to provide vital information on the makeup and functions of biological systems. The FY 1983 request would provide for continuing efforts to define the normal structure of key biological molecules and cell components, characterize DNA damage and repair mechanisms and study how tissues may be damaged when the body's cellular defenses are impaired. To accommodate this higher priority research there will be some selected reductions, chiefly in the area of cell biology.

The Nuclear Medicine Applications program for which $18.5 million is requested in FY 1983 supports R&D on new ways to use radiation and radioisotopes to diagnose and treat human disease. Nuclear Medicine examinations have been and continue to be important in identifying abnormalities and diseases of the heart, lungs, kidneys, skeleton, central nervous system and other body organs. Many physical problems can now be diagnosed and treated without surgery as a result of these developments in nuclear medicine.

This transfer of the technology into commercial use remains a goal of the program. In fact, the Nuclear Medicine Applications program has produced the technology for more than 60 million nuclear medicine diagnostic and therapeutic procedures performed annually and has developed most of the diagnostic instrumentation now in use in nuclear medicine, including the Positron Emission Transaxial Tomograph (PETT).

While previously available technology was limited to defining an organ's shape and form, the PETT scan can tell how that organ is functioning, and how it reacts biochemically to a variety of conditions. Researchers are using the PETT scan to study blood flow and metabolism in the heart and blood vessels to better understand the mechanisms of heart attacks and strokes. PETT scan studies of the brain are being used to determine therapy for stroke or seizure victims and to better understand certain emotional disorders. The scan also has potential application in determining drug therapy for cancer patients.

Recent advances include the development of labeled pharmaceuticals for use with the PETT scanner to study brain metabolic differences in epilepsy, schizophrenia, stroke and diabetes; improved scanning techniques for bone cancer which have raised two year survival rates sixfold; and development of techniques for successfully treating eye cancer, while preserving vision and for detecting small lung tumors not visible by X-rays.

Research that, in the past, has led to these very important developments will continue in FY 1983. The FY 1983 budget request would also provide for expanded research to gain a better understanding of cardiovascular physiology in man and to achieve earlier diagnosis of cardiovascular disease. Using radioactive compounds, research on residual injury to human cells and organs caused by pollutants also would be completed and research on new forms of nuclear cancer therapy would be initiated.

Finally, $0.7 million of the $1.7 million capital equipment request for General Life Sciences and Nuclear Medicine Applications is requested for completion of the biological beamline at the National Synchrotron Light Source at Brookhaven. The increased beam intensity available at the NSLS will significantly extend this research program by revealing the changing structure of macromolecules, such as DNA, during their biological reactions. This knowledge will advance our understanding about the way pollutant materials modify normal biological processes.

Mr. Chairman, let me briefly comment on General Sciences Program Direction.

GENERAL SCIENCES PROGRAM DIRECTION

The FY 1983 budget request for General Sciences Program Direction is $2.0 million (Table 5). These funds are requested to provide for the salaries, benefits, travel and other expenses associated with 36 full-time equivalents in the Office of the Associate Director for High Energy and Nuclear Physics, the Division of High Energy Physics, the Division of Nuclear Physics, Life Sciences Research and Nuclear Medicine Applications program, and associated support staff. The staffing requirements remain constant relative to FY 1982. The increased funding is to provide for normal increased personnel costs such as within grade and merit increases, and benefits.

I would now like to discuss the programs under the Energy Supply R&D appropriation, beginning with Basic Energy Sciences.

Table 5

General Sciences Program Direction
Budget Authority
($ in Millions)

	FY 1982 Estimate	FY 1983 Estimate
Operating Expenses	$ 1.9	$ 2.0
Staffing FTE (OTFTP)	34 (2)	34 (2)

BASIC ENERGY SCIENCES

The Basic Energy Sciences program conducts long-term research to provide a fundamental base of scientific and engineering knowledge for use by government and the private sector to develop new concepts, materials and processes important for energy production and use. Support of this basic research is an investment in our nation's future economic well-being, both in terms of the knowledge produced and the training of university students who will be tomorrow's scientists.

To say that the BES program sponsors research in the physical and biological sciences, engineering and mathematics does not convey the magnitude of a program that supports approximately 1100 research projects a year and provides advanced research facilities that are used by university and industrial researchers as well as national laboratory scientists. Nor does it convey the impact of a research program whose benefits cannot be predicted or scheduled. While we cannot predict the specific long-term impact of most basic research activities, experience during the past few decades makes us confident that the cumulative effect of research underway will be a wealth of new information that will lead to new and improved energy technologies and will enable us to address problems with present energy systems.

The many accomplishments flowing from research carried out by this program during the last year include:

- Development of a new method for fabricating a class of less brittle materials called intermetallic compounds. These compounds have excellent corrosion resistance which is important for energy applications including automotive and industrial uses. In the past, they have seen limited use because of their brittleness.
- Discovery of a new class of chemical compounds that can be used to recover and purify selected valuable elements, such as palladium from nuclear waste solutions.
- Discovery of a liquid membrane to enrich the oxygen content in air. Oxygen is important for efficient combustion, and crucial for high Btu coal gasification. The new liquid membrane is an improvement over state-of-the-art solid membranes; with it, oxygen-enriched air could be produced at great savings in energy and cost compared to present day technology.
- Discovery of a micro-organism that is capable of converting the waste gas, carbon monoxide, into commercially-valuable, larger molecular weight chemicals such as acetic acid. This conversion, which can be accomplished without energy input from other sources, could provide a more economical process for the chemicals and plastics industries among others.

o Development of a combustion process diagnostic technique that, by improving our understanding of flame constituents and characteristics, will help build our ability to tailor fossil fuels to meet operating requirements of combustion systems and reduce pollutant emissions.

This latter example, the initiation of research on combustion phenomena, is an excellent example of the dynamic nature of the Basic Energy Sciences program. The BES program does not have a static technological end point toward which it strives. Rather, the program is responsive to new research opportunities and needs that flow both from ongoing research and from work in new areas. The need for combustion research was first identified several years ago when DOE was established. Working with members of the research community and the Department's technology programs, the general needs for combustion research were identified.

It was determined that the longer range technologies would benefit from an improved understanding of combustion processes, including identification of the species present in flames and their concentrations, chemical interactions at the atomic and molecular levels, and a better understanding of fluid dynamics and turbulence in flames and combustion systems. With the needs and opportunities for research on the fundamentals of combustion identified, we undertook design and construction of a unique facility at our Sandia-Livermore Laboratory. This facility was designed around the special experience in laser diagnostics that had been developed at the

Laboratory to serve nuclear weapons needs. The Combustion Research Facility (CRF) was dedicated during 1981 and has been designated as a user facility where DOE-supported scientists from various locations, university researchers and privately-supported industrial researchers alike can conduct research. Work at the CRF has implications not only for improved fuels, but for higher efficiency engines, cleaner and more efficient coal combustion, and knowledge on the extent and future control of pollutants.

Other promising areas of research supported by BES have wide-ranging applications. Energy storage needs associated with solar energy, electric vehicles, and central station power plants are being investigated by BES-sponsored researc in a number of areas, including chemical reaction kinetics, solid electrolytes, high temperature thermodynamics, electrodes and electrochemistry, high temperature corrosion, and diffusion and gas transport. While these areas of fundamental research are, no doubt, foreign to the average person, I can assure you that investigations into their domain are essential if we are to make significant improvements in our current technologies and develop new ones. Similarly, in response to the need for long-term safe isolation of nuclear wastes, BES is supporting research in radiation effects on materials, thermodynamics of ceramics and brines, fluid flow in porous media, canister materials, actinide chemistry, mechanical and transport properties in geologic systems and other areas. This research provides important additional information to help us resolve issues related to nuclear waste management such as permanent disposal, interim storage, and separation of nuclear waste components.

In order to maintain the kind of high quality research I have just described, we must continue the strong core program that now exists. We must also be able to expand research in emerging priority areas not yet included in the core program as well as maintain, operate and update the major facilities required to carry out the research.

The FY 1983 budget request for Basic Energy Sciences is $282.9 million (Table 6). Of that amount, $261.3 million is for operating expenses; $18.2 million is for capital equipment; and $3.4 million is for construction. This is an increase of $39.6 million over the FY 1982 appropriation for this program. However, 17% of this increase is for the Stanford Synchrotron Radiation Laboratory (SSRL), currently supported by the National Science Foundation. The budget increase reflects, in part, a $6.8 million interagency transfer for SSRL. At the requested funding level for FY 1983, most of the ongoing core programs would be supported although some reductions would still be required in the larger subprograms so that we can support increases for major facility operation and research. Although some program expansion would be possible in the newer subprograms of Biological Energy Research, Advanced Energy Projects and Engineering, Mathematics and Geosciences, most of the increase would support the operation of BES's major research facilities, including the SSRL.

Adequate support of the BES scientific facilities is vital to the productivity of these programs. These facilities include not only the Combustion Research Facility, but synchrotron light sources, research reactors, the

Table 6

Basic Energy Sciences
Budget Authority
($ in millions)

	FY 1982 Estimate	FY 1983 Estimate
Operating Expenses	$226 3	$261.3
Capital Equipment	16.4	18.2
Construction	0.6	3.4
Total	$243.3	$282.9

Intense Pulsed Neutron Source and large electron microscope facilities at the DOE laboratories. These research facilities provide capabilities that are, in most cases, unique in the U.S. and in some cases in the world. They are available to the agency's technology programs as well as to a wide spectrum of the scientific, academic and industrial communities. The costs of maintaining, operating and updating these facilities have been steadily increasing as a result of escalating power costs, significant increases in costs for fabricating new nuclear fuel elements and costs for operating newer facilities as they are completed. Additional funds requested for FY 1983 are mainly to operate the major facilities near their FY 1982 levels, although funding for the newer National Synchrotron Light Source, the Intensed Pulsed Neutron Source and the Combustion Research Facility still would not allow operation at optimum levels.

The FY 1983 budget for BES includes a number of programmatic shifts of funding and management responsibility. As mentioned earlier, the BES program will assume full budget and management responsibility for the Stanford Synchrotron Radiation Laboratory previously supported by the National Science Foundation. SSRL is a national user research laboratory associated with the High Energy Physics facility known as SPEAR located at the Stanford Linear Accelerator Center (SLAC). In addition to serving the High Energy Physics program, the SPEAR facility provides synchrotron radiation to SSRL for research in materials and chemical sciences, physics, engineering, biology and basic and applied subfields.

The transfer is part of the Administration's effort to improve management and planning for national user facilities by assigning to a single agency lead responsibility for a facility. The shift brings support for the two major synchrotron radiation user facilities, SSRL and the National Synchrotron Light Source at Brookhaven National Laboratory, into a single appropriation.

The second programmatic change involves the transfer of all low energy nuclear physics research from the Basic Energy Sciences program to the Nuclear Physics program. This change transfers $12.8 million in FY 1983 from BES to the Nuclear Physics program and represents a management decision to consolidate both management and budget responsibility for all basic nuclear physics research in a single program. The nuclear data and isotopes production activities remain in BES.

Finally, the budget for BES includes shifting of operational and funding responsibility for research reactors to specific single subprograms within BES. Previously, funding responsibility was shared by several other ER programs. This change streamlines responsibility and management accountability for the research reactors.

The next program I will discuss is Biological and Environmental Research.

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

As a result of research supported by the Biological and Environmental Research (BER) program, we are gaining a better understanding of the ways in which energy-related pollutants affect human health and the environment. More specifically, the BER program supports long-term research to determine the physical and chemical nature of energy-related products and waste material; to understand how pollutants move through and are changed in the environment; and finally, to identify pollutants that are toxic to humans and understand quantitatively how those pollutants affect living organisms, including humans. The information developed by this program and by the Life Sciences program allows early analyses of biological issues in parallel with technological and economic analyses of energy options. I believe that this is a far more productive and cost-effective approach than "after the fact" research and imposition of corrective measures such as retrofits and operating restrictions.

The BER program, which is carried out at the agency's multiprogram laboratories, specialized biomedical and environmental labs and over 75 universities, hospitals and research institutions across the country, has made and will continue to make significant contributions to our understanding of biological and environmental systems. As with any long-term scientific research program, a recitation of only a few research accomplishments, particularly recent ones, often does not convey the true importance and implications of a program. With the perspective of time, however, I believe that the very broad impact of the BER program can be seen. As a result of some 30 years of BER-supported basic and applied research, the fundamental principles of radiation biology are now known and understood. This knowledge provides the basis for setting radiation protection guidelines, and aids in the beneficial use of ionizing radiation and radionuclides in medicine, agriculture and other fields. The radiation instrumentation research program is largely responsible for the current state-of-the-art detection systems; and research related to radiation health protection has produced most of the radiation dosimetry techniques in use today. In addition, the entire field of radioecology was developed under the BER program. Research in radioecology, which studies the effects of radiation on and through the environment, has led to new insight and breakthroughs in understanding the cycling and fate of pollutants in the environment and food chain. Developments in radioecology established the concept of studying the environment as an integrated medium for the cycling and transport of pollutants.

Some of our more recent accomplishments include the following:

o Development of an efficient method for integrating two types of analyses to test for toxic pollutants. By analyzing chemically complex mixtures, such as coal conversion products, and testing the mixture's components for mutagenic or carcinogenic properties, it has been found that a single class of organic compounds, representing only a few percent of the total mass of the mixture, is responsible for over 90 percent of the total biological hazard.

- Development of a laser fluorescence system called the "spill-spotter" that is now being used in coal conversion operations to detect contamination of surfaces by organic material. This system aids considerably in reducing worker exposure to these materials.
- Development and application of new, sensitive techniques that detect toxic effects resulting from human exposure to energy-related chemicals and radiation. These include blood cell tests that measure genetic damage to the whole body, methods to identify abnormal proteins in body fluids and tissue, and methods to detect genetically controlled skeletal abnormalities.
- In a continuing study of atomic bomb survivors of Hiroshima and Nagasaki and their first-generation offspring, it was found that there were no significant genetic effects or growth retardation; however, strong relationships were shown between radiation dose and certain cancer incidence rates, mental retardation and other effects related to exposure in the womb.
- Preparation of maps showing the sensitivity of different Arctic environment to particular stresses. These are being utilized by federal, state, and industry personnel in Alaska to select optimal sites for energy-related activities and to determine areas that should get immediate attention after accidental spills.

These accomplishments, past and present, have two common elements. Their benefits become evident only over the long-term and are made possible by Federally-funded research. It is reasonable to assume that industry will carry out the research necessary to comply with Federal and state health and environmental regulations. However, it is both appropriate and necessary for the Federal government to support long-term research on the wide-ranging health and environmental implications of a variety of energy technologies. Federally-sponsored biological and environmental research, such as that supported by the BER program, can help us, as a Nation, to compare some of the cost and benefits of technology options and make wise choices.

The FY 1983 budget request for the BER program is $129.8 million (Table 7). Included in this request is $121.3 million for operating expenses, $7.5 million for capital equipment and $1.0 million for construction. The FY 1983 request represents a decrease of $35.1 million below the FY 1982 budget. That decrease is largely in operating expenses and represents a shift in emphasis toward analyzing the long-term generic health and environmental effects associated with the production and use of various energy options, with less emphasis on short-term, process-specific research.

The proposed FY 1983 budget would support those efforts that neither industry, regulatory agencies or basic health science agencies will address. The FY 1983 budget request would sustain long-term research to define more precisely the quantitative risk estimates for cancer, genetic effects, and other biological changes following acute and chronic low doses of radiation exposures in animals and exposed human populations. Although reduced support would be provided for health and environmental research and

Table 7

Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1982 Estimate	FY 1983 Estimate
perating Expenses	$151.3	$121.3
apital Equipment	9.7	7.5
onstruction	4.0	1.0
Total	$165.0	$129.8

assessment of synthetic fuels derived from coal and oil shale, and of renewable resources, the longer-term issues associated with these nonnuclear activities would continue to be investigated. The FY 1983 budget also would support continued research to analyze the movement and dispersion of pollutants in the atmosphere, fresh water, terrestrial and marine environments; to develop enhanced pollutant detection and measurement instruments and to analyze the interactions between energy-related chemical and physical pollutants with living organisms. The capital equipment request of $7.5 million would allow us to replace and maintain the specialized and sophisticated equipment needed to support the research program. The construction request of $1.0 million would be allotted to general plant projects.

Next, let me turn to the Magnetic Fusion Energy program.

MAGNETIC FUSION ENERGY

Fusion has the potential of becoming a principal energy option for the nation early in the next century. This potential is based on a number of important features. For example, the fuel reserves for fusion are vast, readily available to all, and are free from the threat of embargo. The environmental and safety aspects of fusion reactors appear to be acceptable; and there are multiple perceived end uses for fusion energy. Although electricity generation is an obvious application, other uses are possible as well, including breeding fissile material for fission plants, generating very high grade heat for industrial applications, and the direct production of synthetic fuels.

Because of both the cost and the long-term nature of this highly complex scientific and engineering program, it is the Administration's policy that fusion is an appropriate program for federal support. It is not the Department's policy to take the shortest road, irrespective of cost, to fusion power production, nor the most expedient, if that road does not lead to a realization of a socially desirable fusion system. Rather our aim is to find the best road for developing this complex field of science and technology to ensure that we develop fusion systems that are both environmentally sound and economically competitive. To accomplish this objective, we must provide a base of understanding and knowlege from which sound judgments can be made on the most economical and practical way to develop one of the last known sources of energy - the energy source of the stars.

The program's long-term strategy is to conduct a broad-based program along two concurrent lines. One line is the engineering effort aimed at developing experience with the practical problems of creating and maintaining a burning plasma. A Fusion Engineering Device (FED) integrating the engineering technology required for practical utilization of a burning plasma, will be the central element of this effort. The other line is one of scientific investigation involving two principal goals: (1) development of reactor concepts that promise reactor characteristics significantly better than current concepts; and (2) resolution of the remaining technical issues crucial to the production of the burning plasma. The synthesis of these two efforts will help us to demonstrate fusion's engineering feasibility and lay the groundwork for a rational assessment of fusion's highest potential as a practical energy source.

While the program's long-term strategy involves these two lines of investigation, the current program is devoted primarily to exploring the physical properties of burning plasmas under conditions that approach temperatures and confinement parameters that must be reached to demonstrate scientific feasibility.

The scientific and engineering feasibility goals are a logical outgrowth of the Fusion program's thirty year history. That historical continuum reflects the many changes that have occurred in what has become a very complex and expensive program. Early researchers were optimistic that fusion could be controlled and turned easily to the production of energy. That optimism was dispelled in the late 1950's when it became clear that substantial scientific research would be needed before scientists would be able to confine plasma gases long enough and at high enough densities and temperatures to produce a net energy gain. During the 1970's, systematic progress occurred on a broad front as the result of a carefully planned program. The required temperatures for self-sustaining releases of fusion energy were achieved in several experimental devices and vast improvements in plasma confinement were achieved. We can now predict with confidence that net energy producing systems are possible; and it is now generally acknowledged that there are a variety of scientific paths to practical fusion reactors.

The term magnetic fusion stems from the fact that the fusion fuel consists of charged isotopes of the element hydrogen which are contained or "confined" by magnetic fields within a vessel. There are two main classes of experimental magnetic fusion devices, open and closed. Closed systems, of which the tokamaks are the best known, are systems within which the magnetic field lines circle in on themselves in the shape of a doughnut or toroid. Although much work remains to perfect the closed magnetic concepts in general, the tokamak is the best understood of all magnetic confinement devices and, therefore, the most advanced fusion concept.

The mirror concept is an open system where the magnetic field lines are squeezed near the end of a straight section to retard leakage of the fusion fuel. These cylindrical-shaped devices are referred to as mirrors because most of the particles are reflected back rather than escaping from the ends. In recent years, significant progress has been made in improving this device.

Through research into these two confinement systems, fusion research also has advanced the state-of-the-art in important and diverse technologies, including superconducting magnets, high power radiofrequency tubes and hardware, advanced materials development and mathematical methods for computers. Much of this technology is applicable to other fields. Fusion also makes important contributions in advancing electronics, computer control systems, optics and many other areas.

The Fusion program has made significant scientific progress in recent years. In the Confinement subprogram, new plasma heating techniques were tested and detailed studies were carried out on plasma confinement and scaling. Advances were made in superconducting magnets. Preliminary concept definition studies for a Fusion Engineering Device, the central element of the engineering phase of the program, were completed and progress was made on continuing and completing major facility upgrades and construction of new technology facilities.

Under the Confinement subprogram in the tokamak area, assembly and check-out of virtually all systems for the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory will be completed in December, 1982 in preparation for reactor operation and, ultimately, demonstration of scientific feasibility. The Doublet III tokamak will be upgraded with a new larger D-shaped vacuum vessel to verify theoretical predictions that the D shape allows for a higher plasma beta. ("Beta" is a term which describes the ratio of the plasma pressure to the magnetic field. The higher the "beta", the better confined is the plasma.) The higher beta is a crucial element in the design of a Fusion Engineering Device. Other tokamak test facilities will continue investigations of the scaling of the fusion parameters of confinement time and plasma beta; and a new modest-sized advanced toroidal facility will be initiated to exploit recent scientific advances.

Activities related to the mirror program in the confinement area include continued construction, although at a slower pace than previously planned, of the Mirror Fusion Test Facility-B (MFTF-B) at Lawrence Livermore National Laboratory. MFTF-B is a major scaling experiment for the thermal-barrier tandem mirror concept. When completed, MFTF-B will be the largest facility in the world capable of investigating the mirror fusion concept. In a series of tests completed February 4, 1982, the superconducting magnet was successfully tested at its full design operating current. The MFTF-B magnet is the largest superconducting magnet in the world, weighing in at 789,000 pounds and standing 25 feet high. With MFTF-B, mirror plasma parameters 100 times beyond those of current experiments can be investigated. The key scientific issues of the thermal barrier concept will continue to be addressed in the near-term in the recently-completed Tandem Mirror Experiment-Upgrade (TMX-U) at Lawrence Livermore Laboratory. Thermal barriers are produced with microwave heating and neutral beam pumping to improve the operating performance by allowing hotter plasmas to be confined for a longer time and improving the ion stability. Results from tests of thermal barriers on the TMX-U will be used to optimize experiments on MFTF-B. Further advances on thermal barriers are also being made with current efforts concentrated on axisymmetric configurations. The TARA mirror experiment at MIT is being constructed to investigate this improvement in thermal-barrier tandem mirror design.

Table 8

Magnetic Fusion Energy Budget Authority ($ in millions)

	FY 1982 Estimate	FY 1983 Estimate
Operating Expenses	$292.7	$358.6
Capital Equipment	42.0	39.5
Construction	119.1	46.0
Total	$453.8	$444.1

In the Development and Technology subprogram, construction is being completed on the Large Coil Test Facility at Oak Ridge National Laboratory where six large field superconducting coils will be tested, including three from U.S. industrial participants. The Tritium System Test Assembly facility will also begin operations to develop the technologies essential to the deuterium-tritium fuel cycle.

The activities in FY 1982 and plans for FY 1983 emphasize scientific rather than engineering activities largely as a result of the need to reduce Government expenditures. We have made some necessary, difficult decisions that will require delays, stretch-outs and some postponements of several large construction projects. Although we cannot follow an ambitious funding path this year, these decisions were based on the goal of maintaining enough flexibility so that the key scientific and technical issues in the toroidal and mirror programs will continue to be addressed.

The FY 1983 budget request for the Fusion program is $444.1 million (Table 8). Of that amount, $358.6 million is for operating expenses; $39.5 million is for capital equipment; and $46.0 million is for construction. The total budget request represents a decrease of $9.7 million from the FY 1982 level. This change results from an increase of $65.9 million to the operating budget offset by decreases of $2.5 million in capital equipment and $73.1 million in construction.

The increase in the operating budget provides for maintaining essentially the FY 1982 level of effort in the Applied Plasma Physics activity which supports research performed on the mainline devices, aimed at providing new understanding, techniques, and concepts. The FY 1982 level of effort in the Development and Technology subprogram also would be maintained in FY 1983. This subprogram develops the engineering and technological bases needed to demonstrate the engineering feasibility of fusion, including the design studies for a Fusion Engineering Device. During FY 1982, the Fusion Engineering Design Center at ORNL is continuing detailed engineering for the FED preconceptual reference case design. Physics investigations also are being carried out with the aim of developing advanced concepts to improve the reference case design. In FY 1983, a small effort will maintain the capability to start detailed design work on the FED in the future. Specifically, the FED design will be kept up-to-date and new physics results will be evaluated in terms of their potential impact on FED design. Thus, results of the base scientific program will feed into FED with the dual goal of reducing scientific uncertainty and producing a design that will result in increased performance and cost effectiveness.

Under the Planning and Projects subprogram in FY 1983, work will continue on both the Tokamak flexibility modification to TFTR and the MFTF-B construction project. Increases in the Confinement Systems subprogram would restore operating levels in toroidal experimental devices to FY 1981 levels and allow us to initiate efforts on the fabrication and upgrade of two critical toroidal devices, the Advanced Toroidal Facility and Doublet III. In addition, assembly and preparations for operation of TFTR will be completed and TFTR will begin operations.

The decrease in the construction request reflects, in part, TFTR's transition from a construction to an operational phase. It also reflects decreases in EBT-P and FMIT construction funding. Due to budget stringencies, these two projects will not be funded for construction in FY 1983 and MFTF-B will be funded at a rate below the planned level.

The budget request I have just described would support a meaningful scientific program. It would allow us to pursue important research efforts logically and efficiently with the goal of developing a sufficient base of information to allow technology development to proceed with minimum risk in the future.

I will now describe the Energy Research Analyses, University Research Support, and General Purpose Facilities programs. The FY 1983 budget request for these programs is shown in Table 9 following my discussion of the programs. Before I discuss these outlay progams, however, I would like to comment on the advisory responsibilities of the Director of Energy Research.

ADVISORY AND ASSESSMENT ACTIVITIES

The Director's advisory responsibilities include serving as the principal science advisor to the Secretary on energy R&D programs, on oversight of the non-weapons multiprogram laboratories and on the education and training of scientists and engineers. The Office of Energy Research also provides staff support to the Energy Research Advisory Board (ERAB) whose members advise the Secretary on the Department's energy R&D programs. The Board's membership includes representatives from industry, universities, energy users, state and local governments and public interest groups. ERAB now reports directly to the Deputy Secretary of the Department of Energy. Staff support is provided through ER's Director of Science and Technology Affairs Staff.

Within the Office of Energy Research, the Office of Field Operations and the Office of Program Analysis (OPA) support the Director's advisory responsibilities. The Office of Field Operations Management supports the Director with regard to oversight of the laboratories and energy-related manpower development and training activities. This Office has developed several management tools used by the Department in administering its laboratories and R&D facilities across the country and continues to manage the University Research Support and the Multiprogram General Purpose Facilties outlay programs that I will discuss shortly. The Office of Program Analysis, on the other hand, provides energy research analysis support.

ENERGY RESEARCH ANALYSES

The FY 1983 budget request for Energy Research Analyses is $2.6 million (Table 9). The Office of Program Analysis (OPA) administers the Energy Research Analyses program and provides technical support to the agency through the Director of the Office of Energy Research. The functions and activities of this program include:

1. Assessment of the adequacy of the long-range (technology base) research in support of the agency's programs to develop energy options.
2. Independent analyses and technology assessments of the agency's research and development programs to guarantee their quality and relevance.
3. Coordination and liaison for resolution of major technical issues and research policy developments.

Typical of the technology base assessment function was the assemblage of a prestigious group of industrial and university scientists to assess the long-range research needs in coal gasification, coal liquefication and oil shale. These assessments have been used by the agency to develop R&D programs, by the Synthetic Fuel Corporation to assess project readiness and by industries to define their own research agendas. Similar studies addressed biomass and plant-derived hydrocarbons, salinity gradient solar ponds, materials research needs to improve performance, and durability of solar heating and cooling systems.

Independent analyses of programs such as alcohol fuels, use of methanol for automotive transportation, electrochemical storage, breeder reactor and solar photovoltaics were carried out during the past year to provide management with a realistic assessment of their technological status and potential. In addition, OPA has provided an in depth review of the quality and relevance of research programs supported by the Office of Energy Research, including Basic Energy Sciences and Health and Environmental Research.

Activities related to the interagency coordination of difficult technical issues focused on acid rain in FY 1982. Currently, OPA assists in the planning of agency-supported acid rain research, coordinates acid rain issues and activities across agency offices, and represents the agency on the Interagency Task Force on Acid Precipitation. Also, OPA has initiated the development of a goal-oriented comprehensive R&D plan for all Federal acid rain research.

The FY 1983 budget request would provide for: (1) approximately five ER-initiated major technology area assessments; (2) an update of portions of the agency's Technology Base Assessment; and (3) selected technology studies as requested by senior DOE management.

UNIVERSITY RESEARCH SUPPORT

The agency's major contribution to university education and training of new professional-level manpower is through the funding of the highest quality individual research proposals involving both faculty members and graduate students. We estimate that over 6,000 graduate students currently are supported by DOE, either directly on research projects or indirectly through the laboratories. The agency is also a significant user of technical manpower. Its 57 plants and laboratories alone utilize over 100,000 contractor employees. It is our specific policy to support energy research and training programs aimed at the utilization of unique agency laboratories and equipment by both university faculty and students. We also provide support for refueling specialized university nuclear research and training reactors located across the country. These activities, in addition to the direct support of university researchers provided by our own basic research programs, continue to be appropriate and effective energy research education and training programs. They are aimed at securing top quality energy researchers and at broadening the pool of experienced scientists from which Government, universities and industry draw trained scientific manpower. The FY 1983 budget request of $5.1 million, a reduction of $5.5M from FY 1982, would concentrate these efforts in two high priority areas (Table 9).

The first is the University Reactor Fuel Assistance Program, which supports university nuclear research and training reactors on university campuses. The program specifically provides support for the fabrication and related shipping costs of the nuclear fuel used in university reactors. There currently are 54 such reactors in operation in the U.S. Without our support, most of these reactors would be hard pressed to continue their dual functions of nuclear research and the training of undergraduate and graduate students in nuclear science and engineering. The FY 1983 request of $1.6 million would allow us to fuel up to five reactors plus associated spent fuel shipping and partial support for reactor operational costs when these reactors are "shared" with researchers at neighboring schools.

The other high priority URS activity is the University-Laboratory Cooperative Program. This program (along with user research facilities) is one of the most important mechanisms we have to sustain the close working relationships between our National Laboratories and the academic community. Through this program we support a range of faculty and student research participation activities at all of our major Laboratories. In many cases, these are summer research programs, while in other cases research appointments for faculty members and graduate students are made for an entire academic year. The requested budget for this program in FY 1983 of $3.5 million will support an estimated 2,000 university participants throughout the Laboratory network. Special emphasis again will be placed on providing research opportunties for engineering faculty and students.

MULTIPROGRAM GENERAL PURPOSE FACILITIES

The Multiprogram General Purpose Facilities program, initiated in FY 1981, provides a mechanism for rehabilitating and replacing non-defense general support facilities which are essential to the continued effective and safe operation of the multiprogram laboratories. These facilities include roads, railroads, site utilities and support buildings such as laboratories and office buildings.

The 12 multiprogram labs serviced by this program received over $3.1 billion in FY 1981 to carry out the agency's technology and basic research programs. The replacement costs of the existing facilities exceeds $8 billion. A backlog of $2 billion worth of GPF improvements has developed over the years. This program has begun to address that backlog and has taken management steps to assure that the problems responsible for the backlog will be corrected.

During stringent budget years it is often tempting to postpone necessary replacement or rehabilitation of deficient facilities in favor of maintaining the maximum amount of program effort possible. We have learned from the experience of our predecessor agencies that such expediencies lead to negative impacts on the very programs they aimed to protect and also result in an inventory of billions of dollars in corrective measures which some future generation will be expected to undertake. We plan, therefore, to continue the MGPF program, which began in FY 1981, as a necessary cost of doing business as long as the multiprogram laboratory facilities are utilized to perform research and development functions for the agency.

The FY 1983 request of $34.0 million would allow continued construction on ten projects started in prior years and this year and would fund initiation of four critical new projects in FY 1983 (Table 9). This represents a slight increase over the $32.6 million appropriated in FY 1982.

ADVISORY AND OVERSIGHT PROGRAM DIRECTION AND POLICY AND MANAGEMENT

The FY 1983 budget request for Advisory and Oversight Program Direction is $3.2 million, a net decrease of $0.1 million from the FY 1982 level. These funds are required to provide for the salaries, benefits, travel, and other expenses associated with 41 full-time equivalents funded by this program. This staffing level represents a decrease of 15 full-time equivalents from the FY 1982 level. The decreased salary requirements associated with that staffing reduction are partially offset by increased requirements such as normal salary and benefits increases for remaining staff, and severance pay.

The FY 1983 budget request for Policy and Management is $0.4 million, a decrease of $0.6 million from the FY 1982 level. These funds are required to provide for the salaries and related expenses associated with 8 full-time equivalents in the immediate offices of the Director, Office of Energy Research, and the Director, Office of Management. This staffing level represents a reduction of 14 full-time equivalents from FY 1982.

Mr. Chairman, this concludes my testimony. I would be pleased to answer any questions at this time.

Table 9

Energy Research Analyses, University Research Support,
Multiprogram General Purpose Facilities
Budget Authority
($ in millions)

	FY 1982 Estimate	FY 1983 Estimate
Energy Research Analyses	$ 3.0	$ 2.6
University Research Support	10.6	5.1
Multiprogram General Purpose Facilities	32.6	34.0

Senator DOMENICI. Thank you very much. Let me just ask you a couple of questions and then we will take the other two witnesses.

Why don't you go ahead and proceed?

Dr. SCHRIEVER. I will just briefly summarize the remarks that we have submitted for the record.

STATEMENT OF DR. RICHARD L. SCHRIEVER, DIRECTOR, OFFICE OF INERTIAL FUSION, DEFENSE PROGRAMS, DEPARTMENT OF ENERGY

Dr. SCHRIEVER. As you know, inertial fusion is included as part of the overall defense programs of the Department of Energy.

Since 1976, the inertial fusion program has been a distinct entity alongside the weapons research, development, and testing activity of military applications.

However, there are areas of research that closely link and that are in parallel and in common between these two areas. The bulk of the inertial fusion research is carried out at the national nuclear weapons laboratories, and inertial fusion is, along with the much larger military applications program, the organizational responsibility of the Deputy Assistant Secretary for Military Applications, Maj. Gen. William W. Hoover.

The near-term applications of inertial fusion research are related to the nuclear weapons physics. In the longer term, if we are successful in understanding the principles of inertial fusion, there is the potential application to the supply of inexhaustible energy for the longer term period of time for this country. However, much remains to be done before we can evaluate that scientific potential.

At the present time, several of the laboratories within the country are conducting inertial fusion experiments that result in the implosion of pellets and the production of neutrons and give us an opportunity to study, diagnose, and learn from these reactions.

However, in these experiments, only a small portion of the fuel burns, and the measured output of energy is only 1 part in 10,000, perhaps, of what we invest to bring that reaction about. As you can see, we are far away from providing a source of energy, but I hope you can recognize there is great potential in the work that we are proceeding with.

DIAGNOSTICS

The effort that we expend in this study goes into basically three key areas, and this is where the people, the activities, and the expenses are applied. I might characterize those areas as, first, diagnostics. We are working with phenomena that occur in billionths or trillionths of a second at very high temperatures and high density. Until this program began to work in these areas, there was no capability to measure and diagnose these phenomena. A great deal of sucessful effort has gone into this problem. The things that have been required, for the most part, have been invented and built within the course of this work.

TARGETS

A second area of activity that absorbs much of our resources is the design, manufacture, and fabrication of these tiny targets that contain the fusion fuel. They are the result of complex computer codes and very precise fabrication technology on a very small scale. I think it is worth stressing that as we broaden our experience through experiments, diagnostic, and modeling of these fusion events, we also broaden the scientific base for weapons research and development.

DRIVERS

The final major activity in our program that has represented a major investment in the past is the development of drivers that provide the energy to compress the pellets. This includes shortwave-length lasers such as SHIVA at Livermore, the particle beam technology that provides beams of ions from the particle beam accelerator at Sandia, and the longer wavelength carbondioxide lasers such as ANTARES at Los Alamos. In addition, there are a number of smaller specialized experimental facilities at the Naval Research Laboratory, at the University of Rochester, and KMS Fusion which also support this work.

I would like to point out that in the decade that we have been working in this area, the diagnostic techniques, the theoretical understanding, and the driver capabilities, have more or less been developed from scratch. When we started, the glass lasers that were used in laboratories were very small with only a few joules of energy deliverable to the target. The high pressure carbon dioxide laser such as the ANTARES had only just been invented; now ANTARES will deliver 40,000 joules of energy as a pulse.

The light ion technology that has high potential and is being used at Sandia had not even been conceived until just a few years ago.

PHYSICS RESEARCH

All of these tools give us an opportunity to study this phenomenon of compressing the pellet, studying its physics, and compressing the matter to very high densities. Without going into the physics, I would point out that there are two important considerations that apply to this program. The first is in relationship to the magnetic fusion program which Dr. Trivelpiece has discussed. These two program approaches use rather difficult technologies—one, the low density and long-time confinement; the other a very high density, short-time confinement. The two are very complementary in their physics. Success or failure in either program does not apply directly to the other.

Second, because inertial fusion works in the area of very high density, high temperature physics, the results that we are able to study are particularly supportive of the weapons research program. Inertial fusion has a potential role both in the energy and in the defense mission. At this time, it is fair to say that in the energy area, we are not nearly as far along in our quest as is magnetic fusion. However, at the same time we do have a near-term immediate payoff in the weapons program.

This gives us, I think, a very special status and opportunity to contribute both to the longer term needs and also to the closer ones.

The facilities that we are building in the program will give us an opportunity to study the physics of igniting the pellet and starting it to burn. We are still perhaps an order of magnitude, a factor of 10, away from being able to build the kind of facility that will address the ultimate benefits of fusion.

Our objectives are to study the physics of these inertial fusion processes, learn to understand how they work, and what would be required in order to achieve a large-scale efficient fusion burn. In the near term, we have an objective to apply these tools to the physics issues related to nuclear weapons, and in the long term to develop the potential or identify the potential for energy.

MAJOR FACILITIES

We might speak for just a moment about the different kinds of people that are working in the program. The major facilities in the near-term applications are those in the national weapons laboratories—Livermore, Los Alamos, and Sandia. Each of these laboratories approach the problem with a different driver technology, but they use a similar set of experimental tools, theoretical calculations, and they share diagnostic and pellet fabrication techniques.

In addition, the University of Rochester, KMS Fusion, and NRL are supporting contractors. The major experimental facilities include the NOVA Laser which will be completed at the end of 1984. We are now planning to build a 10-beam system with short-wavelength color. During 1982, we will complete a two-beam system called Novette to support the experimental program. Novette will be finished and operating in the early part of fiscal 1983. At Los Alamos the ANTARES system will be completed in 1983 and will begin its experimental program. At Sandia we will continue experiments on the particle beam fusion accelerator No. 1. During 1983, it should begin to complete its milestones relative to target ignition. We will be completing the design and continuing the construction during 1983 for the particle beam fusion accelerator No. 2. In addition, we will continue to operate the large glass laser facility at the University of Rochester.

The program we are planning for 1983 had been reoriented to emphasize the completion of the three major facilities now under construction and to utilize these for the next several years to develop a more complete understanding of the physics of inertial fusion. In the near term, we would be orienting our experiments to physics which is relevant to nuclear weapons. We believe we have a well-oriented, well-directed program that will produce results applicable to weapons physics, and will ultimately give us the answer as to whether or not this type of fusion is really a possible source of energy for the country.

BUDGET

If I could refer to chart No. 14 which is at the back of the package, I would summarize the budgets we are requesting in 1983—$105 million for operating expenses; $11 million for capital equipment; and $2.8 million for construction which is relevant to the particle beam fusion accelerator. We have tailored the operating expenses to the facilities that we will have in operation during this period of time; namely, the two beam Novette facility at Livermore, the ANTARES facility at Los Alamos, and the continuing operation of PBFA 1 at Sandia. These operating expenses are in line with the operation of these three facilities until construction is complete on the 10 beam NOVA and the particle beam fusion accelerator No. 2.

Although this funding is a little bit more constrained than last year, we believe it is adequate to operate the facilities that we will have.

Thank you very much.

[The prepared statement of Dr. Schriever follows:]

22(1)

Senate Energy and Natural Resources Committee
Subcommittee on Energy Research and Development

March 19, 1982

THE DOE INERTIAL FUSION PROGRAM

by

Dr. R. L. Schriever
Director
Office of Inertial Fusion

Mission

The inertial fusion program is a part of the overall Defense Programs of the Department of Energy. Since 1976 inertial fusion has been a distinct program alongside the weapons research, development and testing activity of Military Application. However, the areas of research are closely parallel and in fact have some common objectives. The bulk of inertial fusion research is carried out at the national nuclear weapons laboratories. Inertial fusion is, along with the much larger military application program, the organizational responsibility of the Deputy Assistant Secretary for Military Application, General W. W. Hoover.

The near-term applications of the basic physics developed in the inertial fusion program are in the areas of nuclear weapon physics and the simulation of weapon effects. In the longer term, if the feasibility of net energy gain is demonstrated, inertial fusion could become one of the inexhaustible energy supply technologies available to the nation in the next century. Much remains to be done in developing the scientific basis for this potential. I propose to present a brief overview of inertial fusion activities and fit these into the context of the defense and energy missions of the Department of Energy.

Fusion Experiments

Chart 1 is a computer enhanced x-ray photograph of an actual inertial fusion event in the laboratory. This one occurred at the University of Rochester, one of the participating laboratories in our program. Several of the laboratories in the program have reached the stage of producing and learning to diagnose actual fusion conditions produced by laser heating and compression of tiny fuel pellets. The lightest tones visible represent portions of the fuel heated to about 100 million degrees centigrade, much higher than the temperature of the sun's surface. However, in our experiments to date, little of the fuel actually burns. The energy investment is of the order of 10,000 times the energy released. We are obviously still very far from being capable of efficient energy production. I hope it is also obvious that we are on to something of great potential.

Diagnostics

Taking a step back from the fusion event itself, we have the task of creating a picture of events occurring under solar conditions, but in less than a billionth of a second and on a scale of millionths of an inch. The technologies to build the delicate targets, and the elaborate diagnostics mounted on the target chamber to monitor the target permance and implosion history (Chart 2), have had to be developed specifically for this program. Much of the program effort goes into such activities. The results are slowly accumulated and then at some point applied to problems with striking results. This is an important aspect of the uncertainties in all our projections. However, as I will describe shortly, there are some significant applications even in the present research stage of these activities.

Target Fabrication

Moving back another step, the target (Chart 3) -- filled with deuterium and tritium, the heavy isotopes of hydrogen -- looks simple enough but in fact presents complex materials problems, very precise fabrication tolerances, and difficulties in construction on a tiny scale. The designs result from long and expensive runs of complex computer codes that attempt to model the physics as we understand it at a given time. It is worth stressing that as we broaden by experiment, diagnosis and modeling the understanding of the basic physics of fusion events, we also broaden the scientific base of the weapons research and development effort. I do not want to exaggerate the payoff in the near term, but its significance is that this research develops a level of expertise in the laboratories that serves both nuclear weapons R&D and the general area of fusion physics understanding.

Driver Development

Moving back still another step, the energy concentrated on the target could be a short, intense pulse of electromagnetic energy from a giant laser such as the SHIVA neodymium glass laser at Lawrence Livermore National Laboratory (Chart 4), or a stream of charged particles from the light ion accelerator at Sandia, Albuquerque. The Los Alamos National Laboratory's laser uses a different technology -- carbon dioxide gas -- but is comparable in size, complexity and the national investment involved. Smaller, specialized lasers are in operation at the University of Rochester, New York, the Naval Research Laboratory here in the District of Columbia, and at KMS Fusion, Inc., in Ann Arbor, Michigan. These are our major contractors whose efforts are rather well integrated in a lead laboratory/support laboratory relationship. The key point is that powerful short-pulse drivers for fusion targets have been developed over the last decade almost from scratch. Behind these rather impressive driver systems lies a whole range of technical accomplishments in pulsed power supplies, materials development, controls and diagnostics of driver performance. The nation's technology base in high energy lasers and particle beam accelerators, available for a range of potential defense and other uses, has been enlarged to a substantial degree by developments specifically for inertial fusion. The more important question is not whether these can be built and operated -- that has been demonstrated -- but whether we can continue to drive down the size and cost of an ignition driver.

Inertial Confinement Fusion

These elements -- the fusion event, imaging and understanding the results, the target technology, and the high energy laser and particle beam drivers -- are all a part of the fundamental concept that extreme energy density on an extremely short time scale can result in fusion energy release, the process occurring in the sun (Chart 5). We know that this process can be made to occur in nuclear weapons. For about thirty years, efforts to make this occur in a controlled environment have involved magnetic confinement. In magnetic fusion, the fuel is at extremely low density -- of the order of one ten-thousandth of the density of air -- and reactions occur over times of seconds.

The inertial approach removes the time constraint imposed by the need to hold the plasma together for relatively long periods of time. Using the inertia of the fuel mass to confine the reaction (hence the term inertial confinement fusion or ICF), the reactions are completed on the order of a ten-billionth of a second in duration. The fuel must be extremely dense, of the order of 10 times the density of lead.

Two ramifications of the very different time and matter density conditions for inertial and for magnetic fusion should be noted. First, the success or failure either of magnetic or of inertial fusion will tell us little about the potential of the other approach. The physics regimes are sufficiently different that the nation enjoys two independent potential methods of gaining the use of fusion energy. Second, ICF with its instantaneous energy release at a single point and nuclear weapon research are mutually supportive. Nuclear weapon experience gives us important insights into inertial fusion's potential and problems, and conversely, inertial fusion success in the laboratory would give us a tool for investigating some of the thermonuclear physics of interest in nuclear weapons research and the possibility of simulating certain nuclear weapon effects. Thus inertial fusion has potentially a role in both the energy and the defense missions of the nation's nuclear research and technology base. At this point we are not nearly so advanced toward developing an energy technology as the magnetic fusion approach.

Program Status

To summarize the status of inertial fusion, in approximately a decade, since inertial fusion research began in earnest, there have been spectacular strides in both our understanding of fusion physics and in our ability to conduct significant inertial fusion experiments. In that period of time we have progressed from a meager theoretical understanding to the point of being able to calculate with high confidence the design and performance of inertial fusion targets. This theoretical understanding is supported by extensive experimental results from many U. S. and foreign laboratories.

In this same period of time the technology for high power drivers for inertial fusion research has been advanced to the point where driver technology is not currently a limiting factor. Initially, glass lasers were capable of focusing only a few joules of energy on target whereas the NOVA facility now under construction will focus about one hundred thousand joules and will be capable of operation with three different colors of laser light. The high pressure carbon dioxide laser of the ANTARES facility had just been experimentally demonstrated at bench-top scale when this program began. The particle beam technology and the ability to generate intense beams of light ions such as used in PBFA-I have been brought into existence in the later years of the decade of inertial fusion research. The investment this program has made in driver development has paid an impressive return in technology and experimental facilities.

The program has tackled and solved a number of diagnostic challenges. Methods have been discovered and instruments invented and built for measurement of phenomena which had never been observed under conditions of such extreme temperature, pressure and density. Within the program there now exist routine diagnostics which do such things as photograph tiny imploded pellets in their own x-ray light, measure the density of material compressed to hundreds of times normal density, and determine instantaneous plasma density surrounding the pellet using holography. All of these and many other measurements are accomplished on the time scale of billionths and even trillionths of seconds.

Application of our theoretical and calculational capabilities and diagnostic tools to experiments in our major experimental facilities has yielded major progress toward our research goals. As I have shown earlier, we can produce by laser irradiation actual fusion conditions. Over 10 billion fusion reactions have been initiated in a single experiment. Still, however, this is only about 1/10,000 of the energy invested in the form of laser light. We need to compress the fuel to about 1000 times solid density before the fusion products are trapped in and help burn the fuel. We have achieved about 100 times solid density in experiments using the SHIVA laser -- about a factor of 10 off. With facilities now under construction we expect to push much closer to ignition conditions (Chart 6). However, there are enough uncertainties in the physics to warrant caution in predicting how close we may come. Conservative computer-aided projections indicate that we will still be a step away -- short by a factor of 10 or so in energy or power -- from ignition requirements. There is a wealth of physics to be experienced and understood between our present capabilities and the ignition milestone.

Objectives

The sustaining force in the program at this stage is the ability to perform the initial weapons technology applications projected for inertial fusion from its beginning. Using the unique energy and power densities attainable with short-pulse lasers and particle beam generators, we are already able to determine materials properties at high pressures and temperatures not otherwise available in the laboratory. Certain aspects of fundamental fusion physics can be modeled and subjected to experiment using the driver, target design, fabrication, and diagnostic technologies developed in the inertial fusion program. In the near term, with facilities now under development, we expect to be able to begin to simulate some nuclear weapon effects for vulnerability studies. Few research programs enjoy these near-term applications, and we believe they constitute both a strength of the program and a strong direction to our near-term efforts (Chart 7).

Participants

The major facilities, and hence the near-term applications, are centered in the national laboratories whose chief mission is our nuclear defense research and development (Chart 8). The lead laboratories, Livermore, Los Alamos, and Sandia/Albuquerque, are pursuing different driver technologies but essentially similar near-term objectives. There is a large degree of commonality in other elements: the basic computer code for all three is the same, target designs are to a large extent a coordinated effort, and diagnostics and target fabrication technologies are increasingly shared. In addition to its glass laser experiments, KMS Fusion supplies targets or components to other laboratories. The Naval Research Laboratory supports both the laser and particle beam efforts. Rochester, KMSF, and NRL are all involved in the fusion theory and experiments activity. KMSF has pioneered both short wavelength experiments and cryogenic target experiments. Rochester has achieved breakthroughs in short wavelength laser light generation applicable throughout the laser experiments effort. Many direct contractors to these major participants, from Cornell University in the east to the University of Hawaii in the west, support the national program. These contractors are coordinated through the Nevada Operations Office as the decentralized contracting authority.

NOVA

Major experimental facilities in the program include the NOVA glass laser at Lawrence Livermore (Chart 9) for which the conventional construction is nearing completion and laser components are being ordered. During this fiscal year a two-beam system called NOVETTE is being assembled in the former ARGUS laser bay for important scaling experiments using short wavelength laser light. The NOVA laser is now scheduled to operate as a short wavelength laser in FY 1985.

ANTARES

ANTARES at Los Alamos is a carbon dioxide laser, a long wavelength laser, for which the conventional construction is complete. One of the two laser modules (Chart 10) has just been successfully tested. We expect this facility to come on line by the end of FY 1983 as a target experimental facility and a major addition to the laboratory's weapons physics research capabilities.

PBFA

The Particle Beam Fusion Accelerator completed in 1980 at Sandia, Albuquerque (Chart 11) has just recently advanced by an order of magnitude beyond the power level previously achievable from particle beam generators. During FY 1983 this facility will be well along in its planned target experiments.

The Particle Beam Fusion Accelerator II design is nearing completion, and construction to house the accelerator is under way.

OMEGA

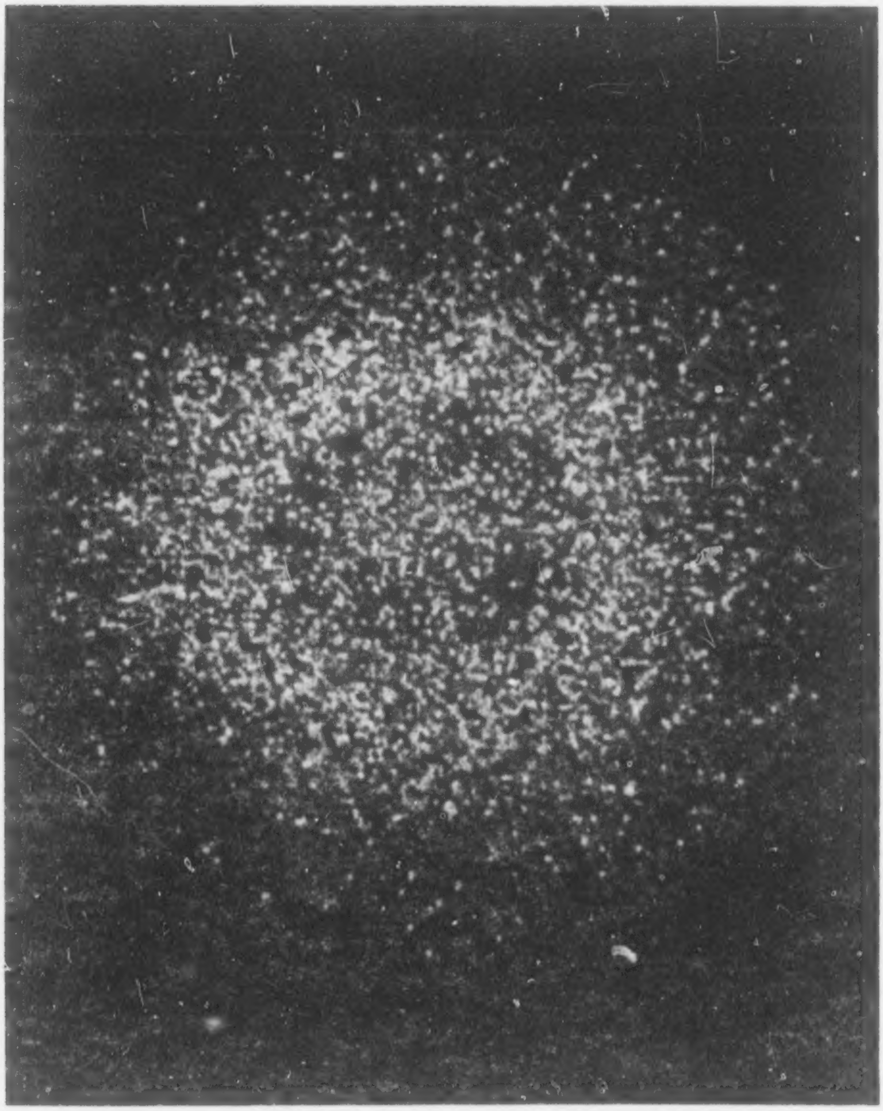
The OMEGA glass laser at Rochester (Chart 12) both supports program activities and also serves as the National Laser Users Facility supported by the University, the State of New York, and a consortium of private companies as well as the Federal Government. An experiment on OMEGA produced the brilliant image of a fusion experiment in Chart 1.

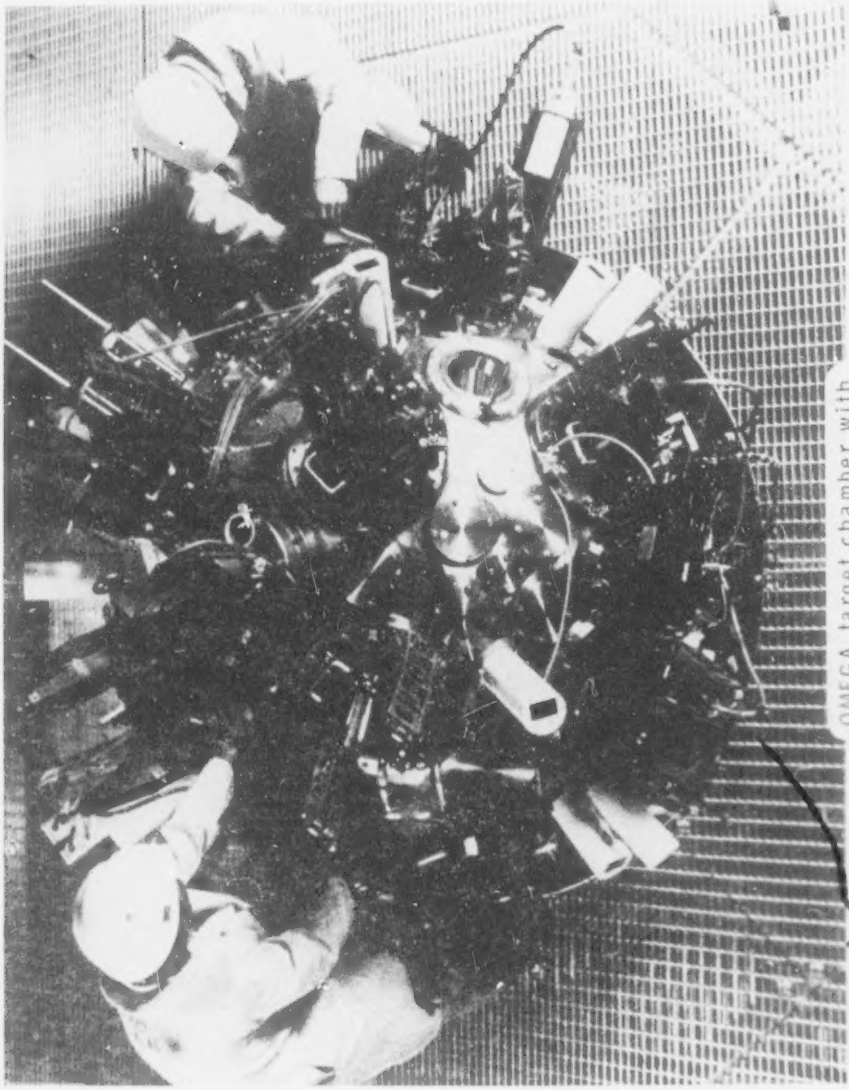
Program Directions

The program which we are planning for FY 1983 (Chart 13) has been reoriented to emphasize the completion of the three major facilities now under construction and intensive operation of these facilities over the next few years to develop a more complete understanding of target interaction physics. We are basically directing the program towards physics experiments which will help us in the understanding of nuclear weapons physics. As our research continues, we believe we will be in a better position to assess the potential of inertial fusion as a future energy source. We now believe that we have a well-oriented, well-directed program that will produce results applicable to the weapons physics area and which will ultimately give us the answer as to whether or not this type of fusion is really a possible energy source for the future.

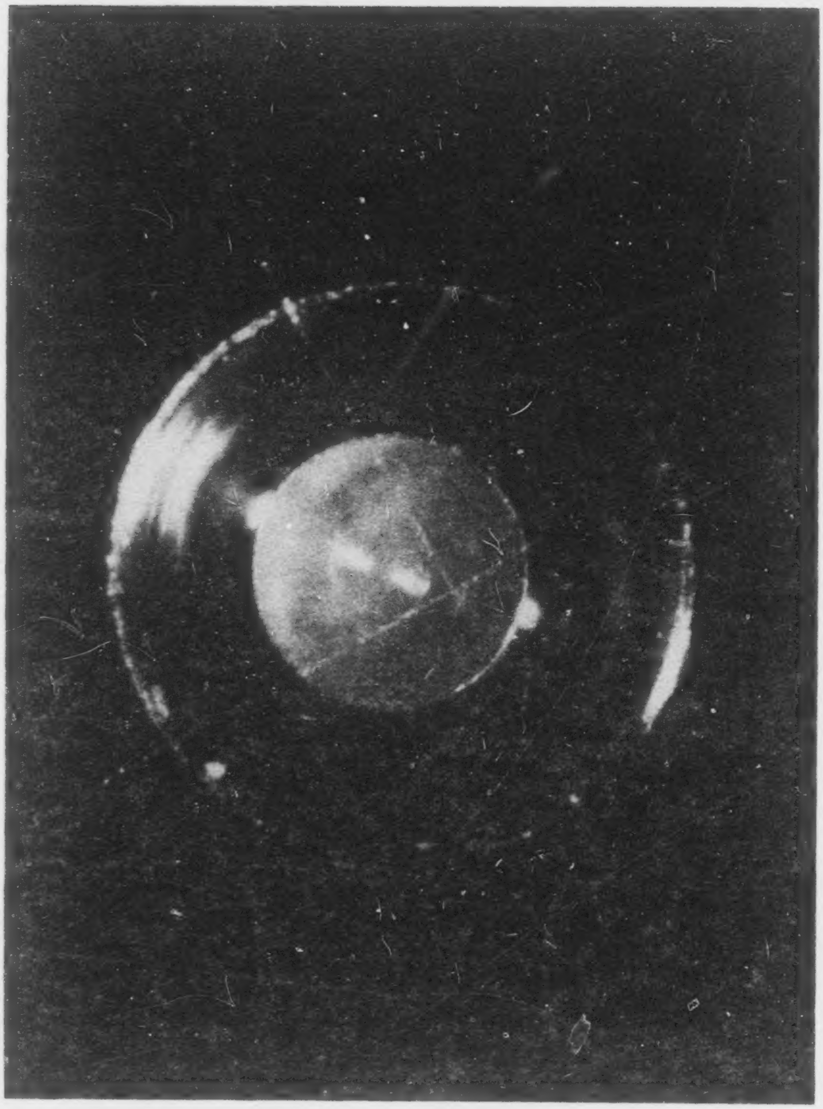
FY 1983 Budget Request

The budget that we are requesting for FY 1983 is summarized in Chart 14. We are requesting $105.0M for operating expenses, $11.0M for capital equipment and $2.8M to continue the construction of the Particle Beam Fusion Accelerator in FY 1983. We have tailored the operating expenses to the facilities we will have in operation. In this fiscal year, we expect to begin operation of a two-beam glass laser at Lawrence Livermore National Laboratory known as NOVETTE. At Los Alamos we will begin the ANTARES carbon dioxide laser experiments and at Sandia we will continue experiments with the Particle Beam Fusion Accelerator I. The operating expenses we have asked for are in line with operating those particular facilities until construction is complete on the ten-beam NOVA and until the Particle Beam Fusion Accelerator II is completed. Although the funding is a little more constrained this year, we believe it is adequate to operate the facilities we have.

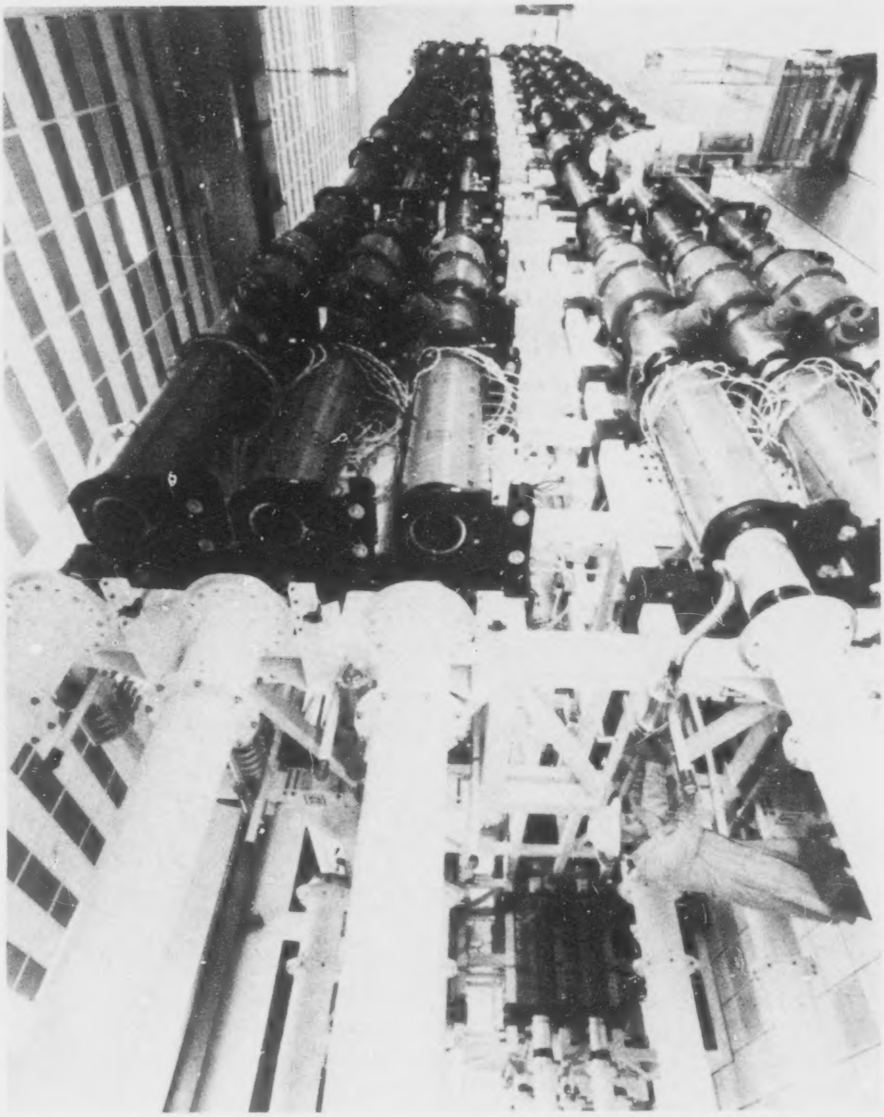


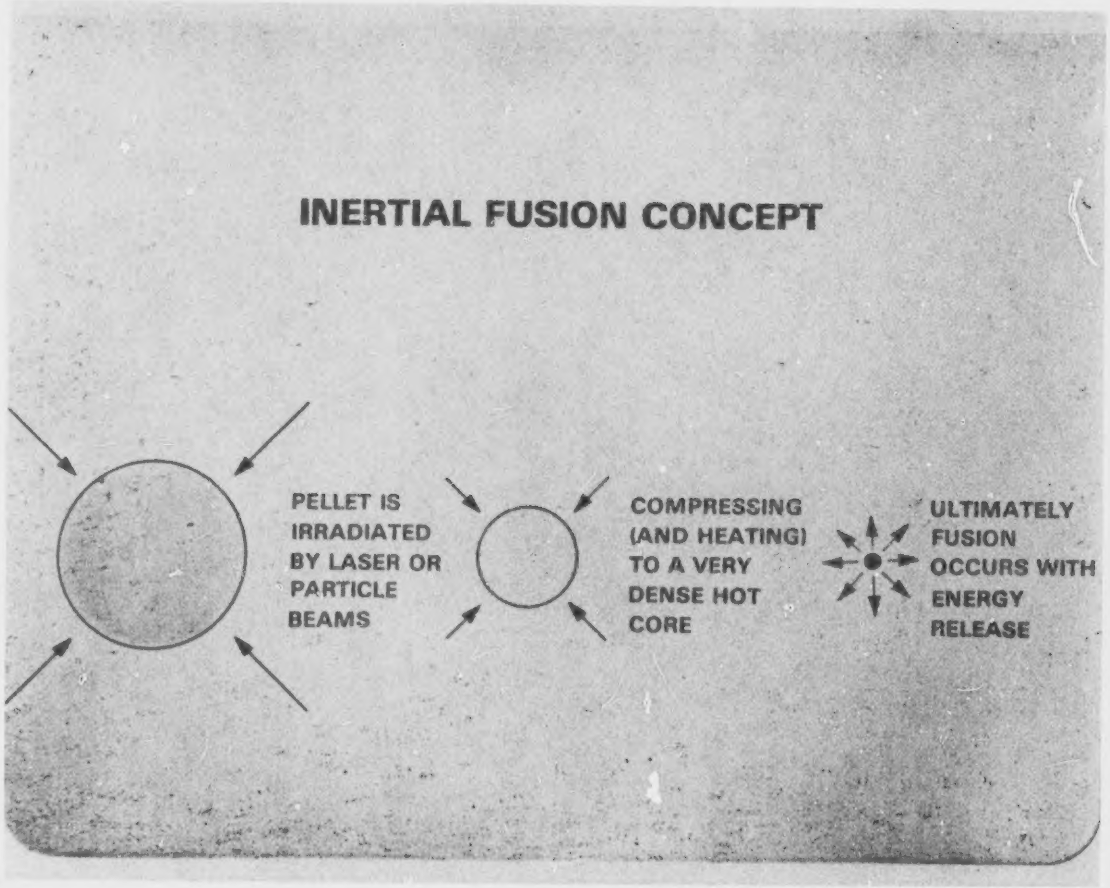


OMEGA target chamber with diagnostics



GLASS MICROBALLOON INSIDE CONCENTRIC PLASTIC AND GOLD MICROSHELLS





INERTIAL FUSION CONCEPT

PELLET IS
IRRADIATED
BY LASER OR
PARTICLE
BEAMS

COMPRESSING
(AND HEATING)
TO A VERY
DENSE HOT
CORE

ULTIMATELY
FUSION
OCCURS WITH
ENERGY
RELEASE

DEPARTMENT OF ENERGY
INERTIAL FUSION PROGRAM

INERTIAL FUSION PROGRAM STATUS

- RECENT EXPERIMENTS DEMONSTRATE FUSION BURN AND HIGH COMPRESSION
- EXPERIMENTAL FACILITIES NOW BEING BUILT WILL ADDRESS ENERGY REQUIREMENTS FOR PELLET IGNITION
- EXPERIMENTS AND THEORY INDICATE ENERGY APPLICATION WILL REQUIRE DRIVER ENERGY TEN TIMES LARGER THAN CURRENT FACILITIES

DEPARTMENT OF ENERGY
INERTIAL FUSION PROGRAM

OBJECTIVES

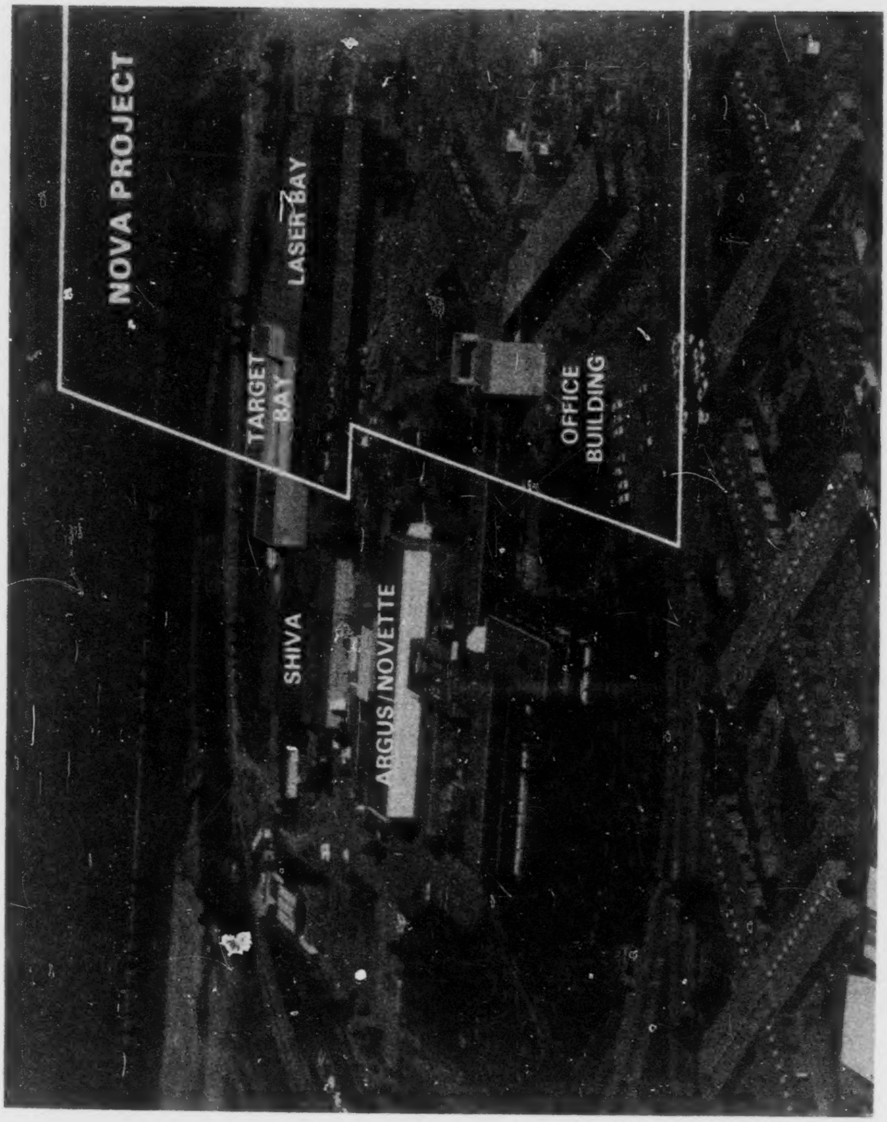
R&D TO DETERMINE FEASIBILITY OF RELEASE OF SIGNIFICANT THERMONUCLEAR ENERGY FROM SMALL FUEL PELLETS HEATED BY LASERS OR PARTICLE BEAMS

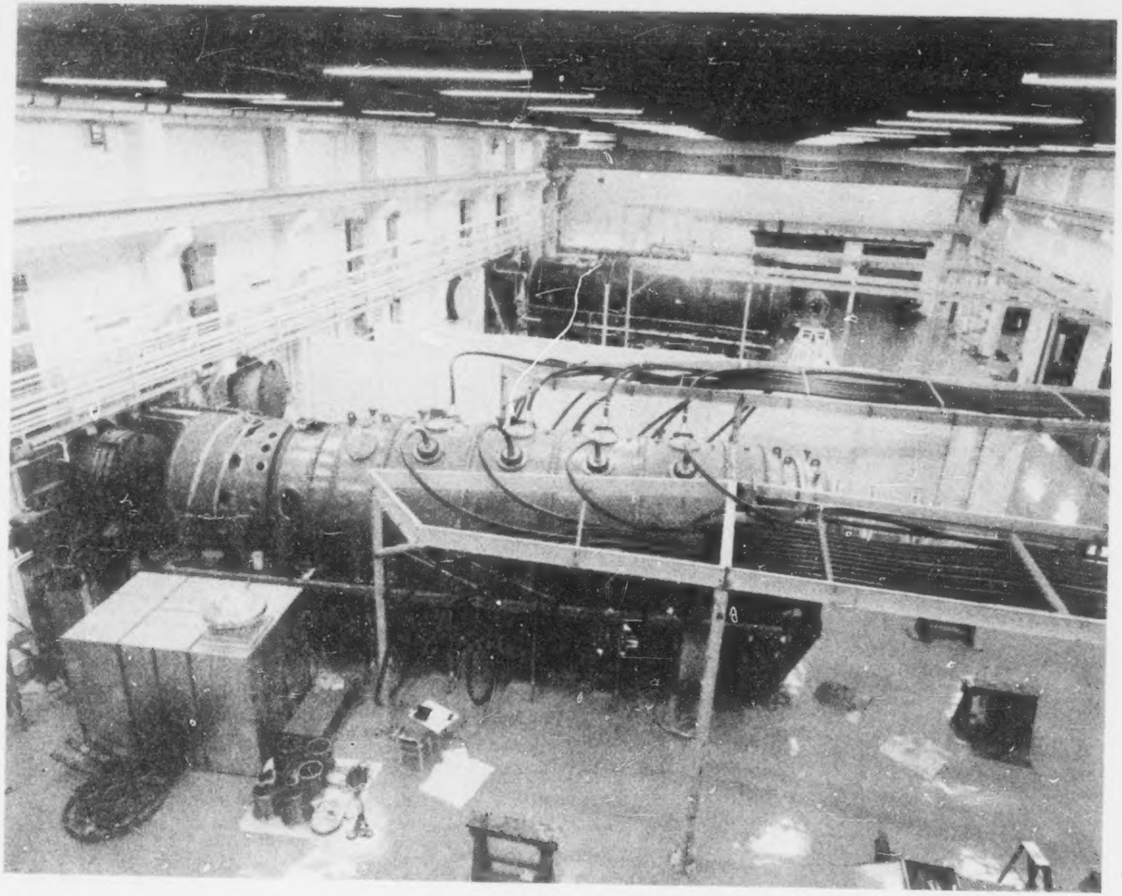
- USE THIS ENERGY FOR WEAPON PHYSICS STUDIES, WEAPON EFFECTS SIMULATION
- DETERMINE ITS POTENTIAL USE AS AN ENERGY SOURCE IF HIGH GAINS PROVE TO BE FEASIBLE

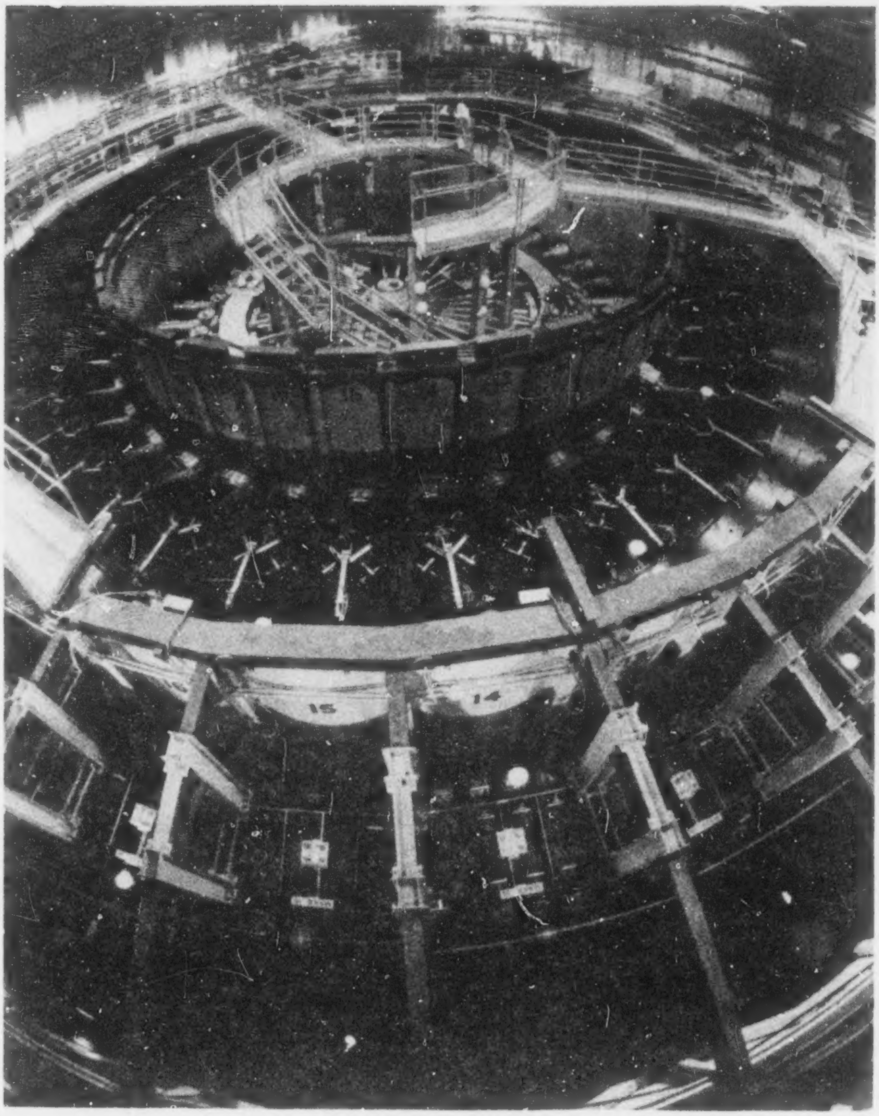
DEPARTMENT OF ENERGY INERTIAL FUSION PROGRAM

PROGRAM PARTICIPANTS

LAWRENCE LIVERMORE NATIONAL LABORATORY LIVERMORE, CALIFORNIA	GLASS LASER EXPERIMENTS
SUPPORTING LABORATORIES:	KMS FUSION, INC, ANN ARBOR, MICHIGAN UNIVERSITY OF ROCHESTER, NEW YORK NAVAL RESEARCH LABORATORY, WASHINGTON, DC
LOS ALAMOS NATIONAL LABORATORY LOS ALAMOS, NEW MEXICO	CO_2 LASER EXPERIMENTS
SANDIA NATIONAL LABORATORIES ALBUQUERQUE, NEW MEXICO	PULSE POWER (ION BEAM) EXPERIMENTS
SUPPORTING LABORATORY:	NAVAL RESEARCH LABORATORY, WASHINGTON, DC


NOVA PROJECT
LASER BAY
TARGET BAY
OFFICE BUILDING
SHIVA
ARGUS/NOVETTE

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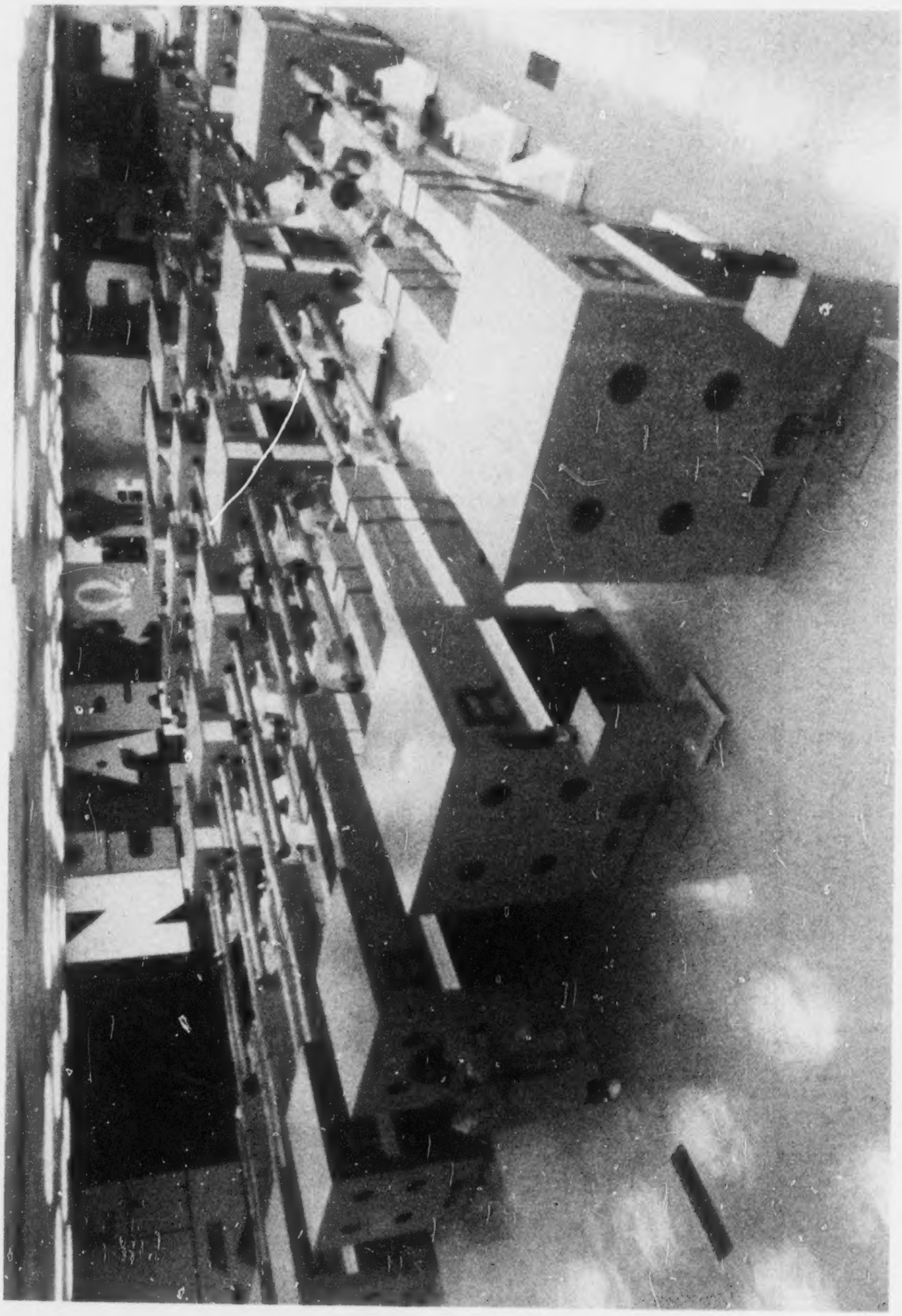


DEPARTMENT OF ENERGY INERTIAL FUSION PROGRAM

PROGRAM PLAN

- DIRECTED TOWARD WEAPONS PHYSICS EXPERIMENTS
- EMPHASIZE COMPLETION OF THREE MAJOR EXPERIMENTAL FACILITIES
  - ANTARES
  - NOVA
  - PARTICLE BEAM FUSION ACCELERATOR II
- SEEK A MORE COMPLETE UNDERSTANDING OF PELLET INTERACTION PHYSICS THROUGH EXPERIMENTS USING THESE FACILITIES
- LATE 1980's ASSESSMENT OF ENERGY POTENTIAL AND FUTURE PROGRAM DIRECTIONS FOR INERTIAL FUSION

DEPARTMENT OF ENERGY
INERTIAL FUSION PROGRAM

(BA IN MILLIONS OF DOLLARS)

	FY 1981	FY 1982	FY 1983
OPERATING EXPENSES	$139.7	$122.4	$105.0
CAPITAL EQUIPMENT	12.6	11.0	11.0
CONSTRUCTION	56.5	75.7	2.8
PBFA-II	5.0	20.0	2.8
TARGET FABRICATION FAC., LLNL	5.5	1.1	0
TARGET FABRICATION FAC., LANL	7.0	7.3	0
NOVA	25.0	37.5	0
ANTARES	14.0	9.8	0
TOTAL	$208.8	$209.1	$118.8

Senator DOMENICI. Thank you very much. I don't know that I agree with your last statement that it is adequate. We will get into that in a minute.

Dr. SCHRIEVER. Very good.

Senator DOMENICI. Mr. Caudle?

Mr. CAUDLE. Thank you, sir. If I might, I would like to just briefly summarize for you the written statement which I am submitting for the record. To help you track my summary, I have prepared a handout which has been provided to you.

STATEMENT OF HON. RALPH E. CAUDLE, DIRECTOR, OFFICE OF SAFEGUARDS AND SECURITY, DEFENSE PROGRAMS, DEPARTMENT OF ENERGY

SUMMARY STATEMENT

DEFENSE PROGRAMS SAFEGUARDS AND SECURITY

MISSION STATEMENT

Protect Classified Information Against Misuse; Protect Nuclear Weapons, Materials and Facilities Against Theft and Sabotage; and Provide Safeguards Technical Support to U.S. and International Activities to Minimize the Proliferation of Nuclear Weapons.

Mr. CAUDLE. The mission of the Office of Safeguards and Security is to work with the other program managers in the Department of Energy to protect classified information against misuse, to protect the nuclear weapons that are in the DOE custody, the materials, those being the nuclear materials and other precious materials such as gold, silver, platinum, et cetera, and the facilities against theft or sabotage.

Additionally, we have the responsibility to provide technical support to the United States and the international activities as necessary to minimize the proliferation of nuclear weapons.

While we are a part of the defense programs organization, the responsibilities that I will discuss are for the total Department of Energy in that we support each and everyone of the program offices.

SECURITY INVESTIGATIONS

Senator DOMENICI. Mr. Caudle, let me just ask you a couple of questions. I want you to finish eventually, but your office is called upon from what I understand to do a phenomenal number of investigations and security checks each year.

Mr. CAUDLE. Yes, sir, that is correct.

Senator DOMENICI. Are all of these thrust upon you, or do you have some way of helping determine whether they are all necessary?

Mr. CAUDLE. I do not have the authority to determine if every request for clearance is necessary. However, DOE policy on this matter is explicit in that requests for clearances shall be submitted only after a determination has been made that the duties of a position require access to classified information, special nuclear material, or regular access to a security area.

Senator DOMENICI. Well, are they all necessary in your opinion?

Mr. CAUDLE. Yes, sir, to the best of my knowledge.

Senator DOMENICI. Do you get reimbursed for these investigations in the agencies directly or how is that arranged?

Mr. CAUDLE. The process is that the offices of the DOE will request the clearances from me. I request the moneys from the Congress for this program which I am discussing. I will show you those numbers later today. Those moneys are really pass-through moneys to me, which I provide to the Office of Personnel Management and to the FBI who actually do the background investigations required for the key clearances.

CLASSIFICATION PROGRAM

Senator DOMENICI. There has been some concern that on the one hand we classify documents that really don't need to be, and on the other hand, there are documents around on the shelf that should be classified.

Now as I understand it, one of your new responsibilities will be in this area. What are we doing now to set an agencywide policy for classification?

Mr. CAUDLE. The Office of Classification, while not directly responsible to me, is continuing their efforts to put out working guidance to all of the agencies or all of the portions of the agencies such that there is consistent guidance throughout the Department.

I have included in my program funding request the dollars for the Office of Classification. It seemed that it was most appropriate to do that because of the modest dollars requested rather than having a separate request. This year for the first time it is part of the total defense program's request whereas in the past the Office of Classification budget request was included in the departmental administration request.

Senator DOMENICI. So it will be line itemed and you will know how much is available?

Mr. CAUDLE. Yes, sir. I will know how much is available.

Senator DOMENICI. Have you had some problems with securing adequate computerization in your efforts?

Mr. CAUDLE. I guess we always have to say that the answer to that is yes. In my efforts specifically in the Office of Safeguards and Security, and also in the Office of Classification, there are literally thousands of actions that have to be monitored, so we are trying to computerize those to the greatest degree possible to assure first of all that headquarters can transmit and receive the information and comments of the people in the field and vice versa;

also that by utilizing the computer we are able to assure consistency in the treatment of information from one location to another.

Senator DOMENICI. I'm with you. I understand you need to get on with that, but what I am wondering about is are we doing as much as we should in this budget to help you get the computers you need?

Mr. CAUDLE. Yes, sir. I think it is a fair treatment of the requirements for my Office.

PROTECTIVE FORCE

Senator DOMENICI. The Department's security forces are made up of, from what I understand, both private contractor groups and Federal guards. Is that correct?

Mr. CAUDLE. That is correct, sir.

Senator DOMENICI. Is your office the focal point for the training for all of these forces, public and private?

Mr. CAUDLE. Let me describe them as being both contractor and Federal, and while I am not directly responsible for the training, I do issue the policy direction regarding guard training. I do provide equipment that supports the training to make the guards more efficient.

Senator DOMENICI. Do you look at the overall adequacy of the protective force, be it Federal or contractor, for the facility or activity? Is that your assessment?

Mr. CAUDLE. Yes, it is my assessment, sir.

Senator DOMENICI. In the past I have been told by a number of facility managers and project managers that their protective forces were inadequate.

Is that so, and are we correcting it or how would you assess it at this point?

Mr. CAUDLE. I would assess it that it is pretty good now, but we do require improvements. A large portion of the funds that I have requested is oriented toward providing better training, and more consistency in training for our guard forces.

Senator DOMENICI. Is not this evolution of contractors providing the security growing now?

Mr. CAUDLE. That is correct.

Senator DOMENICI. In the last 7 or 8 years, we have more and more contractor and less and less——

Mr. CAUDLE. Federal—that is correct, sir.

Senator DOMENICI. Now are you monitoring that so that you are certain that the private contractors are in fact doing what they commit to and living up to their responsibilities to the employees and the like? Is that within your jurisdiction?

Mr. CAUDLE. It is from an overview point of view; my job is to look at the various operations offices which in turn direct the activities of the contractors for whom they are responsible.

Senator DOMENICI. So that as an example, if we just went from a Federal to a private contractor at Los Alamos, a very large transition, you see that it is going to be adequate. Then it is up to Dr. Kerr, who runs the institution on a regular basis, to determine that the contractor is doing his job?

Mr. CAUDLE. He is responsible for the actual operation of the guard force. The Albuquerque Operations Office is responsible to look at him and see what kind of a job he is doing in evaluating guard performance. We look over their shoulder to see how well they are looking at him and we do make our spot checks of the individual facilities to assure ourselves that we are satisfied with the performance that we see.

Senator DOMENICI. OK. I'm sorry. I interrupted. You go ahead and finish.

DEFENSE PROGRAMS SAFEGUARDS AND SECURITY

MAJOR ACTIVITIES

Security Operations
Safeguards Operations
International Safeguards
Technology
Program Direction
Security Investigations

Mr. CAUDLE. In carrying out the major mission, there are six activities which I have described in the folder for you, and there are some pictures which I want to use to demonstrate portions of the effort and the results from the effort.

SECURITY OPERATIONS

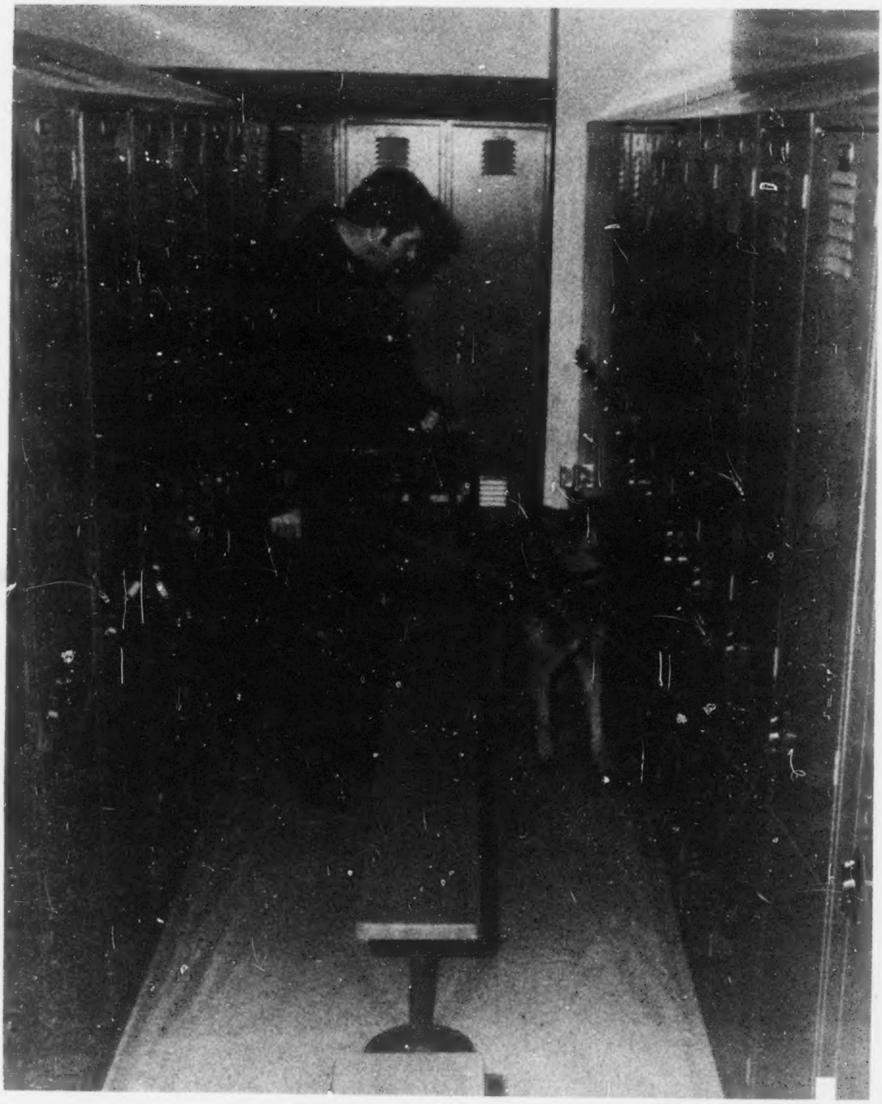
The first major activity which you have alluded to somewhat already is that of security operations. We provide digests of intelligence information which we consider are pertinent to those people in the field such that they are able to understand what the threats might be to the security of their facility.

We also orient a good bit of our resources into Los Alamos, where we have a computer security center of expertise. The main effort there is to determine techniques for improving the security of our computer systems throughout the Department of Energy.

Security operations also include the guard force improvements. We also do threat message credibility assessment under that area. We have people who can look psychologically, linguistically, and technically at extortion threat messages that we might receive, and then be able to advise the people concerned whether or not that threat might be a hoax. We work to provide that service to not only the Department of Energy but to the Nuclear Regulatory Commission and to the Federal Bureau of Investigation.

I have here a picture of a guard and some of the equipment that we have developed and which we are now implementing into use out in the field. This shows the picture of a shotgun which is one of our normal kind of riot control weapons. It has been modified dramatically in capability but not in appearance. It is modified such that it fires a laser beam at sensors which are in place on the opponent during the time that you are doing the exercises. It simulates the recoil, weight, et cetera of the basic weapons which we are using in our protective force. This was developed at Sandia, which is our physical protection center of excellence. We find it gives us an extremely good capability as far as being able to simulate combative engagements with our guard forces.

Additionally, while we have exercised our guards, we have had other agencies come in and participate with us. In all cases the comments on the effectiveness in improving the capability of our guards have been affirmative and very good, so this is a major step forward for us, and I will be procuring more of this equipment this year to distribute through the complex.



Not everything is as sophisticated as the laser weapon which I described. The next picture is of a dog and a guard looking at a locker room. We have found that dogs at this stage of the game are extremely beneficial to us as far as searching our facilities for things like high explosives that one of our own workers might bring in in an attempt at sabotage. Additionally, they are useful, as you know, for drug searches and other protection work.

SAFEGUARDS OPERATIONS

Moving to our safeguards operations, I will show you a few pictures. Our safeguards operations are basically oriented toward implementing the developed components and systems into the field. I am responsible for the development of the components, but the program managers are responsible for paying for the implementation of those activities at their specific sites.

We help the transition from development engineering into implementation. Additionally, in safeguards operations, we have a nuclear materials management and safeguards system, a computer system which tracks all of the United States owned nuclear materials whether it is in this country or in a foreign country.

Additionally, we track the nuclear materials owned by foreign countries that are brought to this country. We are the single network in the Nation for tracking the nuclear materials. We share and work this information with the Nuclear Regulatory Commission.

Additionally, in the safeguards area we operate the New Brunswick laboratory located at Argonne which is the center of excellence for providing standards for the measurements of nuclear materials.

DEFENSE PROGRAMS SAFEGUARDS AND SECURITY

FIELD IMPLEMENTATION ASSISTANCE

Develop Design for the Following:

Hanford (Richland)
- Fuels and Materials Examination Facility – Access Control, Perimeter/Intrusion Monitoring and Communication System
- N-Reactor – Sabotage Protection Through Vital Areas Monitoring System

Savannah River
- Production Reactors – Sabotage Protection Through Vital Areas Monitoring System

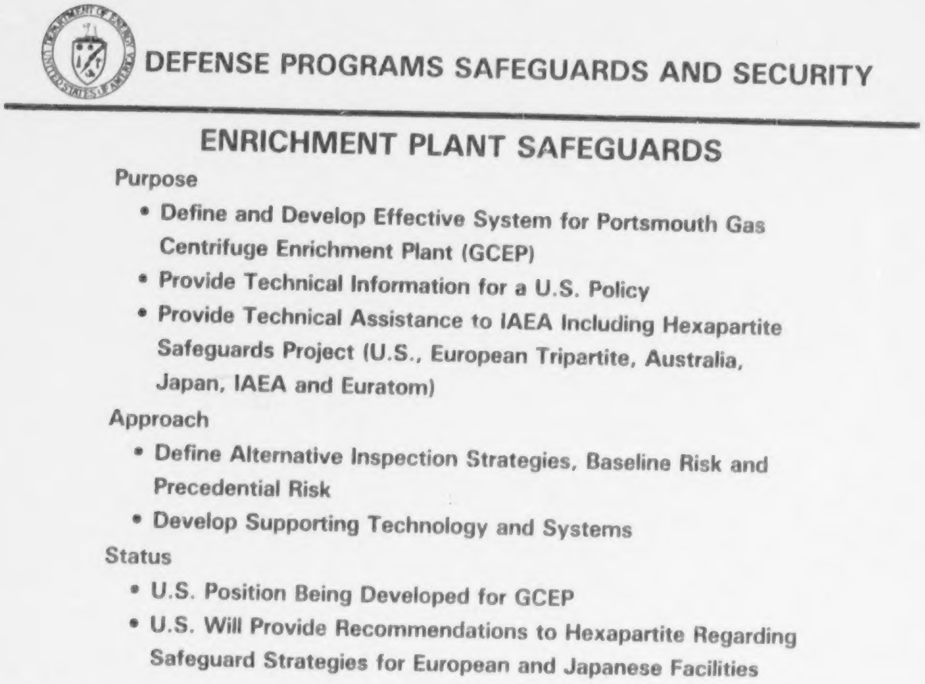
Oak Ridge
- Consolidated Fuel Reprocessing Program/Hot Experimental Facility – Material Control and Accountability System Design
- Y-12 – Vulnerability Analysis and System Upgrades

Idaho Falls
- Idaho Chemical Processing Plant – Perimeter Alarm System and Process Monitoring System
- Idaho National Engineering Lab – Central Alarm Guard Station and Area Monitoring Communication System

Lawrence Livermore Lab
- Vulnerability Analysis System Upgrades

This page shows some of the implementation activities that we are involved in at the present time. At Hanford, in the State of Washington, we are working with the reactors there looking at access control, perimeter controls, communications systems, to improve our security. We are looking at sabotage protection. As we look through that list we see that not only are we looking at the physical protection but we are looking in each of those locations at improvement in our materials control and accountability, still pressing to be able to have absolute control and knowledge of where our nuclear materials are at all times.

Further, as we indicated here at Lawrence Livermore Laboratories, we help them understand the potential threats and what their vulnerability to those threats is and the potential consequences of any of those threat actions.



DEFENSE PROGRAMS SAFEGUARDS AND SECURITY

ENRICHMENT PLANT SAFEGUARDS

Purpose

- Define and Develop Effective System for Portsmouth Gas Centrifuge Enrichment Plant (GCEP)
- Provide Technical Information for a U.S. Policy
- Provide Technical Assistance to IAEA Including Hexapartite Safeguards Project (U.S., European Tripartite, Australia, Japan, IAEA and Euratom)

Approach

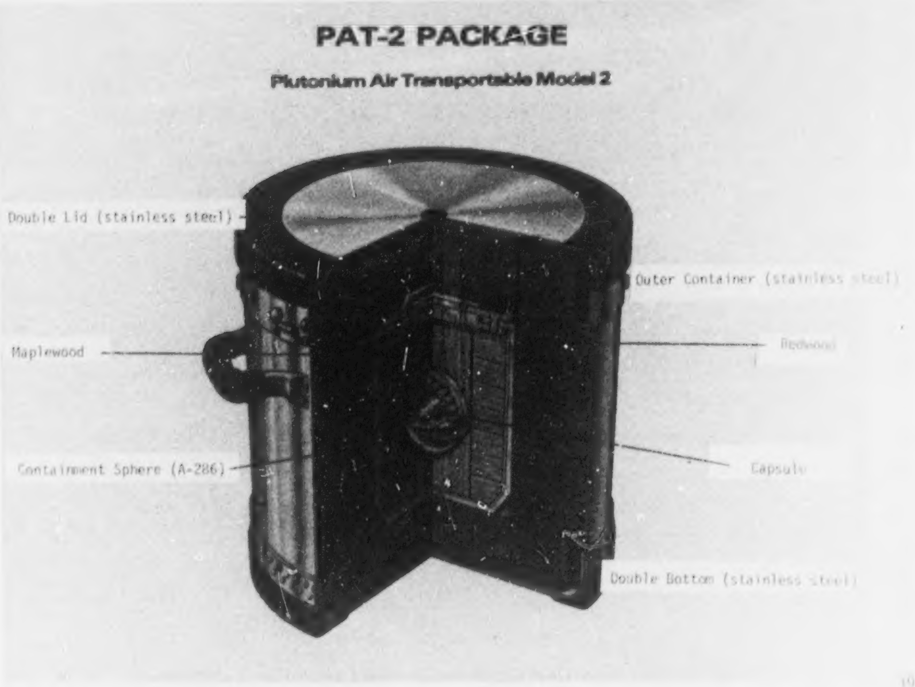
- Define Alternative Inspection Strategies, Baseline Risk and Precedential Risk
- Develop Supporting Technology and Systems

Status

- U.S. Position Being Developed for GCEP
- U.S. Will Provide Recommendations to Hexapartite Regarding Safeguard Strategies for European and Japanese Facilities

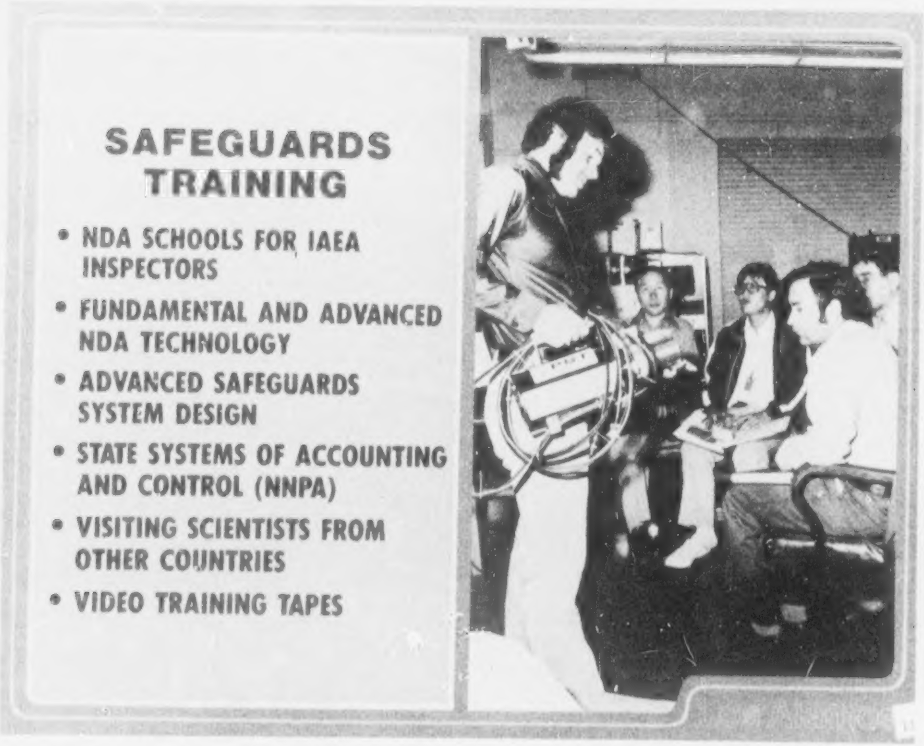
In international safeguards area, one of our major efforts today is looking at a strategy which can be used for the gas centrifuge enrichment plant which the Department of Energy will construct at Portsmouth. That plant most likely will go under the safeguards control of the International Atomic Energy Agency. What we are trying to do at that plant is to develop a strategy which will let adequate safeguards be placed on the facility but yet adequately protect the sensitive technology which is included in the design of that facility.

We are doing this so that by offering this plant we are able to work more easily with the Japanese, with the Germans, and with other countries to provide adequate safeguards as they build and operate their gas centrifuge plants.


PAT-2 PACKAGE
Plutonium Air Transportable Model 2
Double Lid (stainless steel)
Outer Container (stainless steel)
Maplewood
Redwood
Containment Sphere (A-286)
Capsule
Double Bottom (stainless steel)
19

I have a picture of a package called the PAT-2 which is a plutonium air transport package. This was developed at Sandia Laboratory and it gives the ability to ship samples that are taken by the agency inspectors to their laboratory to see whether or not the contents of that sample from a reactor or from a reprocessing plant is as it was stated to be. This was just licensed by NCR and approved by the Department of Transportation this past year—an important step.

We have five of these presently ready to go to the International Atomic Energy Agency for their use.



SAFEGUARDS TRAINING

- NDA SCHOOLS FOR IAEA INSPECTORS
- FUNDAMENTAL AND ADVANCED NDA TECHNOLOGY
- ADVANCED SAFEGUARDS SYSTEM DESIGN
- STATE SYSTEMS OF ACCOUNTING AND CONTROL (NNPA)
- VISITING SCIENTISTS FROM OTHER COUNTRIES
- VIDEO TRAINING TAPES

Additionally, in the international area we are responsible under the Nuclear Non-Proliferation Act to provide training to inspectors for the International Atomic Energy Agency. We also provide information to the individual State members for the design of the materials control and accountability systems which they will want to put into their own countries.

Senator WARNER. Mr. Chairman, if I might interject, this summer I made a special trip to NATO which included these precise programs, and I want to compliment you on the progress being made, and as you know, the chairman and I joined to visit Sandia Laboratory facility and I think you are making some good progress.

Mr. CAUDLE. We are quite proud of the progress we are making.

Senator WARNER. I was delighted to have an opportunity to get out and see some of those programs. I looked at that thing at Sandia to transport that plutonium.

Senator DOMENICI. We saw that out there, what, a month ago?

Senator WARNER. Time flies, Mr. Chairman.

Mr. CAUDLE. We are getting ready to ship them over to Vienna at the present time.

Senator DOMENICI. We are going to have to kind of hurry because we have got some questions and we have to finish in about 15 minutes.

TECHNOLOGY

Mr. CAUDLE. What I would like to do then, sir, having provided you some of the basic descriptions of our capabilities, is simply to show you pictures of some of our hardware and mention that we plan to continue technology development at the Sandia Laboratory, and at Los Alamos.

I will move to the last page which gives an indication of the authorization request that we have this year.

PERSONNEL IDENTITY VERIFICATION
HAND GEOMETRY

SAVANNAH RIVER PLANT
Display and Assessment Console

FISCAL YEAR 1983 BUDGET REQUEST

DEFENSE PROGRAMS SAFEGUARDS AND SECURITY

FY 1983 AUTHORIZATION REQUEST (IN MILLIONS)

	Estimate 1982	Estimate 1983
Nuclear Materials Security and Safeguards Development		
Operating Expenses	$38.4	$37.3
Program Direction	5.1	5.9
Subtotal	$43.5	$43.2
Capital Equipment	3.7	3.7
Construction (GPP)	–	.5
Total, Nuclear Materials Security and Safeguards Development	$47.2	$47.4
Security Investigations		
Operating Expenses	$23.6	$26.0

We are requesting $47.4 million for nuclear materials security and safeguards development which is about the same that we requested for fiscal year 1982. You will note that in the other budget category, security investigations, those are the moneys that pass through to the Office of Personnel Management and to the FBI, there is an increase from $23.6 to $26 million. The primary reason for that increase is the increased cost of each investigation. The request is a straightforward multiplication of the number of required clearances times the unit cost, and that comes up to like $26 million, as near as we could estimate it, during the time that the budget was prepared.

That number is being refined as we review with the field their more accurate forecast of the requirements. At the present time, I believe that I will have need to request an amendment to the 1983 budget to add approximiately $2.5 million to that $26 million.

That concludes my summary. I will be glad to respond to any questions you might have.

[The prepared statement of Mr. Caudle follows:]

STATEMENT OF MR. RALPH E. CAUDLE
DIRECTOR, OFFICE OF SAFEGUARDS AND SECURITY
DEFENSE PROGRAMS
SAFEGUARDS AND SECURITY

Mr. Chairman and Members of the Committee, it is my pleasure to appear before you and address the safeguards and security activities of the Agency, specifically those aspects which are the responsibility of the Office of Safeguards and Security.

The primary mission of the Agency's activities in this area is the protection of classified information, nuclear weapons, materials and facilities against theft and sabotage. My responsibilities as the Directo of the Office of Safeguards and Security are directed in major part towards the development of policies and procedures, as well as components and systems, for assuring such protection. Our program also focuses on providing safeguards technical support to United States and international activities to minimize the proliferation of nuclear weapons. The Agency's security investigations responsibility, which is an integral part of ensuring adequate protection of resources and classified information, also resides within the Office of Safeguards and Security.

The Office of Safeguards and Security supports both operational and developmental activities. The former includes such safeguards and security operations as the Nuclear Materials Management and Safeguards System, the New Brunswick Laboratory and the validation of guard training requirements. Developmental activities in enhancing safeguards and security are carried out largely by the national laboratories and transferred to Agency operations. I should point out that this Office does not fund the actual plant, capital equipment and operating expenses of agency-wide safeguards and security systems at Agency facilities. For example, the safeguards and security systems in the weapons and nuclear materials programs are requested by, budgeted for, and implemented by those programs.

I present this distinction of activities as a framework of reference for you as I direct attention to our FY 1983 funding requirements. Noted on this chart are the budget activities identified in the budget before you.

During the past six months, (since assuming my position as Director of Safeguards and Security) I have reviewed our entire program, and have consulted extensively with individuals within our Agency and the Department of Defense who are devoted to identifying and encountering the diversity and degrees of threats that we must be prepared to counter. As a result, the Agency has made programmatic adjustments which I believe will offer a satisfactory level of protection to the Nation's nuclear community.

We are devoting our efforts towards the continuation of meeting the changing threats and, with recognition of limited resources, are endeavoring to achieve and maintain a reasonable protection level--i.e., a prudent risk level. The requested funding levels will permit us to meet our commitment.

NUCLEAR MATERIALS SECURITY AND SAFEGUARDS

The FY 1983 authorization request for Nuclear Materials Security and Safeguards is $47.4 million. The Nuclear Materials Security and Safeguards program consists of six basic elements. These are: security operations, safeguards operations, international safeguards, technology development, classification, and program direction. For the first time, the Agency's classification responsibilities are included within the Nuclear Materials Security and Safeguards Development budget. I will briefly address the major elements of our Safeguards and Security program.

Security Operations

The Security Operations element of our program provides for the Agency's capabilities to protect classified information and material. Present activities include emphasis in the areas of understanding the potential threats, vulnerabilities and related consequences to our resources and ensuring protective force readiness to deal with adversary challenges. Through the Operations Security program, valuable counterintelligence information related to the foreign intelligence threat is analyzed and disseminated to appropriate Agency components. Additional efforts emphasize computer security and other technical security activities.

New standards and related training programs are being established for the Agency's protective forces. The Multiple Integrated Laser Engagement System (MILES) weapon, which has been modified to shoot harmless laser beams instead of ammunition, is being used extensively in the guard force tactical training program. It has introduced elements of realism and objectivity into both the teaching and evaluation of guard force effectiveness. More than 2,500 protective force personnel, at all of the major Agency facilities, will have had the opportunity to benefit from at least the initial phase of training with the MILES system by the end of FY 1982. Another training program has been developed in conjunction with the Federal Law Enforcement Training Center to prepare Agency protective force personnel for implementation of the recently delegated arrest authority. Consistency and excellence is stressed as we provide the guidance for the field to implement effective site-specific training programs.

Safeguards Operations

I will now turn to Safeguards Operations which involves three major functions: assistance to Agency field operations, the nuclear material control and accountability program which includes the Nuclear Materials Management and Safeguards System, and operation of the New Brunswick Laboratory at Argonne, Illinois.

A high priority effort in our program is providing expert technical assistance to Agency facility managers. This assistance supports application of the latest state-of-the-art safeguards and security equipment and integrated systems. Areas for improvement have been identified through on-site inspections, vulnerability assessments, and field office requests. Site-specific assistance for identified improvements to defense and nuclear materials production program facilities is planned for a number of sites.

At Savannah River, we will assist in the development of systems to: protect thei production reactors against sabotage; account for nuclear materials for the new Fuel Processing Facility; and upgrade the capability of the existing nuclear materials accountability system for the Plutonium Fabrication Facility.

With respect to the Hanford site, we will assist in the development of an advanced system to enhance the protection for the N-Reactor against sabotage, the development of an upgraded safeguards system for the Plutonium Extraction and Purification facility, and the development of a safeguards system for the Fuels and Materials Examination Facility. At the Idaho site, we will assist in developing physical protection upgrades for the Idaho Chemical Processing Plant and an advanced command and control system for the Idaho National Engineering Laboratory's central guard station.

Finally, we will provide assistance to the Lawrence Livermore and Sandia Livermore Laboratories for their respective safeguards and security improvement programs. This assistance is provided through two major Agency laboratories, the Sandia National Laboratories for expertise in physical protection and the Los Alamos National Laboratory for expertise in materials measurement, control and accountability.

The Nuclear Materials Management and Safeguards System (NMMSS) is the sole national nuclear materials computerized data base for tracking the status and location of nuclear materials in the U.S. It serves the Nuclear Regulatory

Commission (NRC) as well as this Agency. The system receives and processes information on 18 types of nuclear materials owned and used by this and other government agencies, as well as nuclear materials leased to or owned by private companies in the U.S. Along with the Nuclear Regulatory Commission, we are jointly studying ways to make this system more responsive to today's challenges.

Heightened concern over the "insider threat" has sparked the need for reexamination of the role of material control and accountability to ensure timely detection of material diversion. Material control and accountability activities planned or in progress include the development of standard statistical techniques to evaluate inventory differences at Agency facilities.

We support the New Brunswick Laboratory which serves the Agency's nuclear contractors, NRC licensed facilities and the international community. This is the principal U.S. laboratory for nuclear material measurements and standards and inventory verification of safeguards inspectors' samples.

I mentioned in my preliminary remarks the Agency-wide budget for safeguards and security. Our function in that specific area is to work closely with the field and program offices in identifying and analyzing deficiencies in safeguards and security systems, and in coordinating followup actions to assure that proper remedial actions are taken in response to these identified deficiencies.

International Safeguards

In the area of International Safeguards, the primary objective is to support U.S. nonproliferation and national security objectives. This program is directly responsible for development of international safeguards systems required for facilities that may become eligible for International Atomic Energy Agency (IAEA) safeguards inspections under the recently enacted treaty between the United States and the IAEA, the so-called "Voluntary Offer."

Our program also engages in joint development and testing of safeguards technology under bilateral agreements with several countries and the European Community (EURATOM). Other efforts in which we are involved directly support the various provisions of the Nuclear Nonproliferation Act. We are conducting training courses for safeguards' personnel from nations developing nuclear programs. To date, we have presented two sessions on materials accountability and three on physical security. More than 100 participants from over 25 countries have participated. We are also conducting discussions with nations receiving U.S. material to assure that physical security measures imposed will be maintained at adequate levels to prevent theft and/or diversion.

Compliance with export/import civil agreements requires the tracking of nuclear materials sent overseas and those received by the U.S. This tracking on an international basis is another function of the Nuclear Materials Management and Safeguards System referred to earlier. Another major effort concerns direct support to the International Atomic Energy Agency. The Office of Safeguards and Security manages a U.S. funded Program of Technical Assistance to the IAEA in response to urgent requirements identified by the IAEA. Also, much of the technology which we develop for domestic application is transferred as relevant to the IAEA to assist them to meet their objectives of effectively safeguarding nuclear materials and facilities world-wide. We are working actively with the Department of State, the Arms Control and Disarmament Agency and the Nuclear Regulatory Commission in this area. Our people and those of the national laboratories are represented on international working groups that support the International Atomic Energy Agency. These working groups assemble information and make recommendations for safeguarding enrichment, reprocessing and other facility types as well as for technology development.

Technology Development

Research and development is conducted on a range of components and systems for physical protection and material control and accountability. Efforts focus on developing components to solve identified deficiencies and provide performance specifications for equipment to be used at existing Agency facilities or new facilities in the design stage.

In the past several years, funding emphasis has been shifted from technology development to current operational problems. Equipment to identify and allow access of only authorized personnel, as well as to prevent entry of contraband will be evaluated in the operational environments at one or more Agency facilities. A broadened base of capability for measuring uranium and plutonium materials will be pursued to reflect the increasing need and benefits of automated, remote measurements in safeguarding materials.

Recent advances in electronics, detector capabilities and automation can be combined to make possible improved methods for material accounting through the development of nondestructive assay instruments which measure materials accurately, very quickly and without having to take samples. In addition, these new methods can be used to measure highly radioactive material on site with a minimum amount of handling, thus limiting personnel access, and opportunities for theft, as well as providing additional control for production and criticality.

In order to avoid duplication in our technology development program, we coordinate our activities very closely with the R&D efforts of the NRC and Department of Defense (DOD). We periodically explore with the DOD the feasibility of joint R&D efforts that would be of mutual benefit to both agencies. We have a substantial physical protection technology base established at Sandia National Laboratories. Routinely, we transfer advanced technology to DOD to assist them in protecting DOD assets in the U.S. and overseas.

Program Direction

Our authorization request includes program administration supporting a total of 139 positions, including 33 for the classification program. It should be observed that many of the functions necessary for the successful fulfillment of my responsibilities are headquarters/personnel intensive. For example, nearly half of my staff is involved in providing security support and in the processing and analysis of over 25,000 security investigations per year.

PLANT AND CAPITAL EQUIPMENT

Before addressing the Security Investigations program, I note that our authorization request contains a modest amount for capital equipment required to support the safeguards and security program I have described. It also includes a general plant project at the New Brunswick Laboratory for the plutonium handling operation that requires alterations for health and safety improvements including modification and upgrade of the exhaust scrubber system and modification and replacement of deteriorating ventilating duct work.

SECURITY INVESTIGATIONS

The FY 1983 authorization request for Security Investigations is $26 million. These funds are used to reimburse the Federal Bureau of Investigation (FBI) and the Office of Personnel Management (OPM) for conducting background investigations on Agency employees, contractor employees, and consultants prior to their being granted access to classified information, classified materials, or special nuclear materials. The background investigation is required by the Atomic Energy Act of 1954, as amended, and by Executive Orders 10450 and 10865 to insure that access to classified information, classified material, or special nuclear material will not endanger the national security.

The FY 1983 budget provides for approximately 15,200 background investigations and 10,800 national agency checks. The majority of background investigations support defense activities but are also required for personnel in the uranium enrichment program and nuclear energy research and development programs.

Although costs for the investigations have risen substantially over the past few years, we have completed a high percentage of the clearances required by the Agency programs and identified to the Congress.

CONCLUSION

In summary, Mr. Chairman, we are requesting an authorization of $47.4 million for the Nuclear Materials Security and Safeguards Program and $26 million for the Security Investigations Program. As I mentioned in my opening remarks, I believe we are on the proper course and, with your continued support, we will continue to improve our effectiveness. This concludes my statement. I will be glad to answer any questions the Committee may have.

DEFENSE PROGRAMS SAFEGUARDS AND SECURITY

MISSION STATEMENT

Protect Classified Information Against Misuse; Protect Nuclear Weapons, Materials and Facilities Against Theft and Sabotage; and Provide Safeguards Technical Support to U.S. and International Activities to Minimize the Proliferation of Nuclear Weapons.

DEFENSE PROGRAMS SAFEGUARDS AND SECURITY

FY 1983 AUTHORIZATION REQUEST
(IN MILLIONS)

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Total, Nuclear Materials Security and Safeguards Development	$47.2	$47.4
Security Investigations		
Operating Expenses	$23.6	$26.0

Senator DOMENICI. Thank you very much.

Let me ask a few questions. Dr. Trivelpiece, you may not be aware of the fact that I am a real staunch supporter of the university research support program. I am because I believe it is tremendously significant even though it is very small in your budget.

One aspect that I am concerned about beyond the graduate level is the postdoctoral assistance. My understanding of that aspect of the American scientific life is that it is very, very important that this country, not just Government, but the country, furnish a kind of a bridge time there because of the postdoctoral student life and their productive research positions.

Could you comment on the need for assistance for our postdoctoral candidates in this respect to bridge that gap?

Dr. TRIVELPIECE. Senator, as a professor of physics for nearly 20 years, I certainly am aware of the problem and sympathetic to it. To the extent that I have some influence over and control the resources, I am dedicated to trying to see what can be done to improve the situation with regard to education and training. In these various areas of science technology that fall within my program purview, we have had to reduce, in a few small areas, some of the programs that are perhaps of interest to you.

Nevertheless, the Department through its R&D program supports approximately 6,000 to 7,000 graduate students in various areas that these programs represent. I couldn't give you a precise answer on the number of people who are falling into that cagetory of postdoctoral and prefaculty or laboratory employment, but I am sure we are supporting people in these groups.

I am aware of the problem. I think a lot of people are aware of it and concerned about it, and I don't believe anyone is against trying to make some correction in those directions. It is really a question of the priorities and relative funds that are available at this time.

Senator DOMENICI. Well, I appreciate your observation. I think you are doing an excellent job in that overall area, and I commend you for it. I hope you stay with it. You will have a lot of support here; if you need any additional support on the Hill or any additional authorizing language that might even give you more discretion, at some point we might sit down and talk about that with some of your people and some of our institutional people to see if they have any ideas.

Dr. TRIVELPIECE. I would be delighted. We have lots of ideas. We have a few constraints.

Senator DOMENICI. Yes. Well, we might not always be constrained. Dr. Schriever, my good friend Senator Warner mentioned our trip, and I want to clarify that we visited Sandia and Los Alamos but that was all that I was with him, just that portion of the trip, I think in the ICF program that there is a tendency on the part of some to think that we have too many efforts and too many machines moving at the same goal.

Now I don't think that is the case, but would you provide the committee with a breakdown of the operating and construction budgets for each of the major participants in this program, including the KMS and University of Rochester and then the staffing levels that have gone along with these funding levels?

As I indicated, it is my sense that some who need to ask assistance from up here would think that they are almost in all respects duplicates, and I don't think that is the case. I am concerned, however, Doctor, that the program is stalling out or at least stalling. Maybe not out, so I would like in addition to that for you to provide us with written comments on the unique capabilities of each of these machines and the programs under your direction and then how those goals differ. If we can get that in one place in the record, I think it will help us here in discussions.

Sometimes I think we need to get that request to OMB also, but they have done their job and you have responded. We will just have to see if we agree or not with their assessment as they work through you.

Dr. SCHRIEVER. We will be pleased to provide that very quickly and work with your staff if there is more they would like. We will provide that.

Senator DOMENICI. I also have an additional question that I will give you. I am somewhat concerned that when you add up the dollars for construction and the reductions in staff that you are not going to get program and construction meshing. If you could answer this question, then we will take a look ourselves to see if we agree.

You obviously are presenting the budget. You have to be confident that it will work. I am not so sure we won't delay some things we shouldn't delay and cut some staff that we will have to beef up rather soon again. I have found that that is not good budgeting and it doesn't save money, and it doesn't make for good programing, but we will just submit that one to you.

Dr. SCHRIEVER. Fine. Thank you.

Senator DOMENICI. Dr. Trivelpiece, I want to talk a little bit with you about the environmental research in biological areas. The reductions there are pretty severe, pretty large, and actually to this Senator look a little bit alarming. Again, I guess we will have to look at it in due course with the appropriators, but there is a 30-percent reduction that I think would destroy a number of environmental programs that I think are of very high caliber. Some may think of them as negative. I hope you don't. I hope you are doing these things because the budget matters, not because you consider the environmental research in biological areas to be negatives.

I know we are moving ahead in a number of new technologies and generally the scientific community has told us that to avoid overregulating or ridiculous regulating, we ought to have scientific data. I think that is what you all contribute immensely to this process. We haven't done that up here in Congress in some time. We have required environmental standards and we don't have the scientific backup.

Are you concerned that with these kinds of reductions in the environmental research and biological research area that we may be shortchanging ourselves and do you really think that the kind of research that you are having to terminate will be done by the private sector?

Dr. TRIVELPIECE. Let me begin by saying I do regard this as a very important area of research. We have had to adjust to the budget stringencies that are confronting all of us. In doing so, we did protect what I believe to be the core scientific activities that are appropriate for this program and terminated one supplement of the program entirely. Otherwise we have spread small cuts throughout various elements of the biological and environmental research program.

I think the prospect that industry will pick up some of this research is probably true in some instances. Certainly many of the oil companies are engaging in their own environmental research to determine the consequences of the things that they produce on the environment and on people.

Nevertheless, there is a continuing Federal responsibility in my view to do the kind of research that will provide the data necessary to develop appropriate regulations and laws to control these things. I think it is unrealistic to expect industry to provide the data by which it will itself be policed in these matters, so I believe that we do have a balanced program. It does do the right kind of environmental research.

We have had to reduce some elements of the program in order to meet the present budgetary constraints.

Senator DOMENICI. I did not get a chance to review your rather indepth statement, so I will ask you to do this for the committee. If it is in there, just make reference to it.

With reference to the environmental research and biological research areas, could you in a very simple way put down what programs, what program expectations were under current law and what you had to do to each one in submitting the budget and what we will not do as a result? Can you do that for us?

Dr. TRIVELPIECE. Certainly.

[The information follows:]

HEALTH AND ENVIRONMENTAL RESEARCH
PROGRAM PLANS AND REDUCTIONS

The Biological and Environmental Research, and the Life Sciences Research and Nuclear Medicine Applications programs represent the Federal Government's only comprehensive research effort which addresses high priority energy-related health and environmental issues. Research is carried out in the areas of human health, health effects in biological systems, ecology, pollutant characterization and monitoring and health and environmental risk analysis. The research is designed to identify, measure and characterize energy-related releases; understand their transport, conversion and fate in the environment; determine their ecological impact; define their potential effects on human health both through direct observations and studies with experimental biological systems; and provide realistic analysis of the interactions between energy activities and human health and environment. A life sciences basic research program supports fundamental biological research in biophysics, cell biology, genetics, chemical physics and instrumentation as a base for the more energy-related program.

Human Health Research uses epidemiological or clinical studies of human populations to determine the effects of exposure to toxic physical, chemical or biological agents. The major effort aims to quantify risk for late effects of acute and chronic exposures to radiation. These studies will continue in FY 1983 at approximately the same levels as in the previous year.

Health Effects Research exploits molecular, cellular and animal test systems to experimentally define dose-response relationships and the factors influencing carcinogenesis, mutagenesis and toxicological risks of energy-related activities. The level of effort will be reduced with the largest decreases occurring in coal-related research ($11 million), the largest part of which ($8.6 million) will be in the liquid synthetic fuels area. Research such as that on the toxicology of products from the SRC and H-Coal liquefaction processes will be eliminated. Other significant reductions in this program will include the conservation, inexhaustible and fission areas. These decreases will be partially offset by increased activity in long range, generic research studies ($+8.5 million) including new methods to identify abnormal proteins in human tissue and fluids, an approach which will permit the detection of a wide range of genetically-determined adverse health effects.

The Environmental Research program conducts research in terrestial, freshwater and marine systems dealing with the movement of energy-related toxic materials through the environment, the resiliency of such systems to impacts and the restoration of damaged ecosystems for beneficial use. The largest decrease in FY 1983 will be in the coal area ($3.4 million) with, again, major decreases in liquefaction and gaseous fuel research. As an example, all bioassay studies of effects of synfuel effluents on aquatic organisms will be terminated. Other smaller reductions will be made related to fission, inexhaustible and solar energy processes.

Physical and Technological Research conducts investigations of the chemical nature of biologically-active energy-related wastes, atmospheric processes which transport pollutants and the science of measurement of radiation and environmental chemicals. Major reductions in FY 1983 are planned in the fossil fuel area ($8.8 million) with individual programs such as the development of methods for characterizing synfuel effluents, diesel exhausts and the combustion products of urban wastes scheduled for reduction or termination. The High Altitude (stratospheric) Sampling Program will be reduced. Increases in longer-term, generic research includes an emphasized program dealing with the validation of long range atmospheric transport models to distances of over 1,000 km by tracer tests.

The objective of the Carbon Dioxide Research program is to improve the scientific understanding of the CO_2 issue. This program will be reduced by $4.0 million in FY 1983. At the reduced level, research on the global carbon cycle, the primary effects of CO_2 on climate, and vegetation effects will be supported. Minimal research on the secondary environmental and societal effects will be supported in FY 1983.

The objective of the Health and Environmental Risk Analysis program is to support the formulation and conduct of Biological and Environmental Research by providing realistic analysis and assessments of health and ecological impact of advanced energy technologies. This activity will be terminated in FY 1983.

General Life Sciences research supports a long term effort that provides the information, concepts, theories and models needed to develop a biological basis for understanding and estimating energy-related risks to human health. FY 1983 decreases of $7.6 million will require a reduction of effort of biophysical studies of the interaction of DNA with energy-related chemicals and radiation, reduction of fundamental studies of cellular behavior and reductions in the development of chemical, physical and biological instrumentation.

Nuclear Medicine Applications research supports the development of the use of radiation and radioisotopes for the diagnosis and treatment of human disease. This area will remain essentially unchanged in FY 1983.

In FY 1983, Capital Equipment, Construction, and Program Direction will decrease by $5.4 million.

Senator **Domenici**. I think that would be helpful to put it all in one little package.

Dr. Schriever, last year my recollection is that we talked with you about the criteria, development of criteria, for transfer portions of the inertial confinement fusion program to the civilian side or DOE.

You stated that you hadn't had time to develop that kind of criteria then.

Have you done anything since then in terms of how we as a Government and policymakers should evaluate, transfer to the civilian side?

Dr. **Schriever**. No, sir, Senator, we have not I think adequately established those kinds of criteria. I might make two points relative to that. There is a distinct reorientation within our program to look at the basic physics processes and not pursue energy as a specific application, but look to develop that potential and so we are not, we don't see that as quite as near term an issue as we did even a year ago.

The second thing I might mention there is that we do, we have identified one area in our program, namely, the heavy ion accelerator technology, which we think has a strong application to energy and relatively little near-term relevance to the military research interest of the program, and so we have come to an agreement, Mr. Roser and Dr. Trivelpiece, that beginning in 1984 we will transfer the responsibility for the heavy ion accelerator technology to Dr. Trivelpiece's energy research. This would be I think an example of how we might see this beginning to happen. Particularly that is one where we feel that the technology that is relevant to energy is most appropriate to be transferred now.

Senator **Domenici**. That is the one that prompts me to ask the question because I understand that you do plan to do that. You have generally arrived at the consensus as I understand it within the Department, but there are no criteria.

I am not necessarily saying there should have been, but I wonder in that respect isn't that half a million dollars program in your request and if you transfer that over, what is going to happen to those research groups? I think they are at Berkeley and Argonne.

Dr. **Schriever**. Let me perhaps overview that a little bit. We have been working in an area, in that area at Argonne, Berkeley, a little bit at Los Alamos, for the last several years. That program effort has totaled something like $5 or $6 million a year. In its early stages it was shared between ourselves, that effort was shared between ourselves and energy research.

In this fiscal year, 1982, we are in a transition period trying to find a way to move this over. Perhaps you are familiar with our authorization language that tells us we should not be funding in that area, and so what we are doing is trying to fund the transition effort and we are putting into that just $2 million into the program at Berkeley in an effort to maintain that as a viable program so there will be something healthy and useful for those people to assume and take forward.

In the 1983 level, we are even more austere and we have allowed only half a million dollars to transfer, to try to keep that transition effort viable until 1984.

Now we would hope to find within our program or in cooperation with someone else more resources because more are needed to keep that thing viable so that it can be taken up and moved forward beginning in 1984.

Senator DOMENICI. So that level is not the level that you think is necessary, but it is the level that you think is justified once the decision is made that it ought to be moving to the civilian side?

Dr. SCHRIEVER. Yes, sir, that is correct.

Senator DOMENICI. So those who want to keep it going and keep the research group together would have to be looking elsewhere to supplement that money because that is all you can justify in transition?

Dr. SCHRIEVER. At this budget level, yes.

Senator DOMENICI. I have no further questions except we will give you the two that I have referred to, and I would appreciate your responses as soon as possible.

Thank you very much. We stand adjourned.

[Whereupon, at 11:05 a.m., the hearing was adjourned, subject to the call of the Chair.]

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

MONDAY, APRIL 26, 1982

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9 a.m., in room 3110, Dirksen Office Building, Hon. Pete V. Domenici, presiding.

Present: Senators Domenici and Ford.

Also present: Paul Gilman and Elliot Chakoff, professional staff members; and Willis Smith, professional staff member for the minority.

Senator FORD [presiding]. We have three panels. The panels each consist of five or six members. It is going to be Senator Domenici's recommendation this morning, and I have to agree with that, that each panel member will be held to 5 minutes in which to make a summary of his prepared statement. Any information that you want in the record that relates to your statement this morning will be included in toto.

We start this morning with panel No. 1 on fossil programs. These oversight hearings are basically to determine what the ramifications will be of the reduction in the budget, the cutbacks on alternate sources of energy as a result of the philosophy that private enterprise will do the most, if not all of the research and development in the future.

Our witnesses this morning on the first panel will include Mr. David O. Webb, Dr. Bernard Lee, George H. Lawrence, William Podolny, Dave Brown, and Joseph Yancik. Dr. Yancik, since you were the last called, you can be the first up to bat and then we will just go right to left with the panel.

STATEMENT OF DR. JOSEPH J. YANCIK, VICE PRESIDENT, RESEARCH, NATIONAL COAL ASSOCIATION

Dr. YANCIK. Thank you, Mr. Chairman. I am Joseph J. Yancik, vice president for research at the National Coal Association. The association represents the country's major underground and surface coal producers, and other organizations providing services to the coal industry.

Mr. Chairman, we have a written statement, which we would like to have included in the record. My purpose today is to convey to the committee that the coal industry considers the imbalance in the proposed DOE energy R&D budget for fiscal 1983 to be counterproductive to our Nation's energy future and also contradictory to the administration's market-oriented principles.

Specifically, the abrupt and major reductions proposed for coal research will constrain the Nation's current and long-term ability to greatly expand the use of coal with the confidence and knowledge that public health and the environment can and will be protected.

I want to emphasize three points that are fundamental to our position. First, the U.S. coal industry remains committed to President Reagan's economic recovery program. We are prepared to share in the sacrifice that is necessary because fewer Federal dollars will be available for energy R&D.

Second, the Nation's best interests are served through a balanced R&D effort that preserves the options of the industrial user to choose the energy fuel representing the optimum choice for the requirements. The energy research budget submitted by the administration for fiscal year 1983 does not preserve the technological options for coal's use. In fact, many useful programs will be stopped in their tracks.

And, third, we urge Congress to authorize and appropriate the necessary funds which will support rationally balanced energy research programs consistent with our Nation's economic capability and energy goals.

We commend the chairman and the subcommittee members for the leadership shown in recommending to the Senate budget committee a preliminary funding level of $416.9 million for fossil fuel research. Certainly, a fossil fuel budget of this magnitude is adequate to support the viable coal R&D program and preserve our Nation's options to increase its reliance on coal.

As the subcommittee is aware, the administration's budget request of $106.9 million would force the premature termination of many ongoing projects and result in a significant loss of potential technological improvements for which this country has already made most of the required investment.

The coal industry continues to support and urges continued funding for DOE's research efforts to complement the activities in the private sector, namely, one, the innovative extraction technologies which significantly reduce health and safety hazards to mine workers and yet offer improved productivity.

Second, coal cleaning and processing systems which reduce sulfur content, ash minerals and other undesirable trace elements in the coal prior to burning.

Third, combustion systems that produce environmentally benign solid and gaseous waste products.

And, fourth, synfuel products using conversion processes that can be environmentally controlled to protect the health and the welfare of plant workers and the local communities.

We also support the immediate transfer of DOE's coal program to the Bureau of Mines, from whence it came at the time DOE was created. By combining the energy program with the larger program at the Bureau of Mines, not only will there be savings in program management costs but also the fragmentation problems which have plagued both programs will be eliminated.

In conclusion, the goal industry supports a reasonably funded Federal research program because we believe that it is an important ingredient to this Nation's ability to accept with confidence our unquestioned long-term dependency on coal.

A balanced energy R&D program must include a commitment by our Government to promote a technological base for advanced coal mining and use techniques that can be developed into improved commercial products by the private sector.

Toward this end, it is essential that we have a viable Federal program with a continuity of research effort pursuing high risk technologies to the point where the industry can carry forward and finance promising developments to commercialization. Through this approach, our Nation will have the opportunity to use its vast reserves of coal without compromise.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Yancik follows:]

Statement of
Dr. Joseph J. Yancik

Before the Subcommittee on Energy Research and Development
United States Senate Committee on Energy and Natural Resources

Hearings on Department of Energy Fiscal Year 1983
Budget Proposal for Energy R&D Programs

April 26, 1982

Mr. Chairman and Members of the Subcommittee:

I am Joseph J. Yancik, Vice President for Research at the National Coal Association. The association represents the country's major underground and surface coal producers, equipment manufacturers and suppliers, consultants, coal sellers and other organizations providing services to the coal industry. I thank you for this opportunity to present the coal industry's views on the Department of Energy's proposed budget for FY 1983 for fossil energy research.

My purpose today is to convey to the Committee that the coal industry considers the imbalance in the proposed DOE energy R&D budget for FY 1983 to be counter-productive to our nation's energy future and also contradictory to the Administration's market-oriented principles. Specifically, the abrupt and major reductions proposed for coal research will constrain the nation's current and long-term ability to greatly expand the use of coal with the confidence and knowledge that public health and the environment can and will be protected. Before I expand on these views, I want to emphasize three points which are fundamental to the coal industry's position.

First, the U. S. coal industry remains committed to President Reagan's economic recovery program. We are prepared to share in the sacrifice that is necessary because fewer federal dollars will be available for energy R&D.

Second, the nation's best interests are served through a balanced R&D effort that preserves the options of the industrial user to choose the energy fuel representing the optimum choice for the requirements. The energy research budget submitted by the Administration for FY 1983 does not preserve the technological options for coal's use. In fact, many useful programs will be stopped in their tracks.

And third, we urge Congress to authorize and appropriate the necessary funds which will support rationally balanced energy research programs consistent with our nation's economic capability and energy goals.

Mr. Chairman, we commend you and your subcommittee members for the leadership shown in recommending to the Senate budget committee a preliminary funding level of $416.9 million for fossil fuel research for FY 1983. Certainly, a fossil fuel budget of this magnitude is adequate to support the viable coal R&D program and preserve our nation's options to increase its reliance on coal. As the subcommittee is aware, the Administration's budget request of $106.9 million would force the premature termination of many ongoing projects and result in a significant loss of potential technological improvements for which this country has already made most of the required investment.

I will now expand on the coal industry's views of selected concerns related to the coal research budget for FY 1983, as proposed by the Department of Energy.

Achieving A Better Balance Among Energy R&D Programs

The Administration's research philosophy, which limits the federal role to long-term, high risk activities with substantial potential payoffs is claimed to be the basis upon which DOE justifies its proposal to drastically cut coal R&D funds. The end product of the application of the Administration's philosophy is a FY 1983 budget for coal research which is only one percent of the total energy R&D budget. This proposal comes at the same time the Administration is also advocating greater use of coal by utilities and industrial users. In the DOE's view, this imbalance is justified because they concluded that most of the coal projects to be phased out were inhibiting or distorting energy producer and user behavior in the marketplace.

It is difficult, if not impossible, to accept that the Department of Energy, in defining market disturbance, used common criteria and applied them in an equal or consistent manner to all energy fuel research programs. We believe that if the DOE had done a fair and equitable assessment, the resulting FY 1983 energy research budget would have had much better balance. It is apparent that the DOE ignored two fundamental criteria normally used in determining research funding priorities. These are (1) the relative, current and future projected use of our nation's energy supply options and their future availability from domestic energy resources, and (2) an assessment of the progress, accomplishments and benefits of ongoing energy R&D programs to the well-being of the American consumer and taxpayer. We firmly believe that a reevaluation of DOE's budget decisions is needed, for this nation can ill afford to turn its back on coal or any viable source of energy on the basis of perceived philosophical views of what does or does not distort the marketplace.

We believe the federal government should allocate, in a responsible manner among all viable energy fuels, whatever research funds are available and that this allocation should be consistent with its role to preserve present as well as future energy options.

Coal Industry Participation in Research Activities

Since 1932, the coal industry has supported modest research efforts on a continuing basis at its Bituminous Coal Research, Inc. laboratory. Currently, many of the larger coal producers have their own research facilities or they sponsor projects at research institutes and universities. Much of industry's ongoing research efforts of necessity have been limited to problem solving rather than the development of new technologies for mining and using coal. There always have been, and will be in the forseeable future, limitations to the amount of research dollars that a company can afford to invest. Two reasons predominate. First, coal markets are highly price competitive. Most small and medium size producers do not have the income base or technical capabilities to conduct research. In practical terms, this establishes a limit to optional expenditures, like research expenses, that larger companies can incur and still compete in the marketplace. Second, coal mining or use techniques or technologies are rarely patentable, nor can they be kept proprietary and protected to prevent other producers or users from reaping their economic benefits. Under these circumstances, it is difficult for individual coal companies to commit large sums of money to expensive or high risk multi-year research projects. This is why cost-shared contracts with the federal government have been attractive to coal companies since some of the burden of long-term financial risks can be shared.

The coal industry has a long history of evolutionary development of improved mining equipment and methods. In this respect, the industry has relied on the marketplace to introduce new products and technologies. We are, therefore, supportive of the new federal research philosophy of having the private sector fund the near-term R&D. It should be recognized, however, that many ongoing federal research projects in coal mining defy simple characterizations as to their stage of development. Near-term objectives should not be confused with the readiness of the technology for commercialization.

We believe it is unrealistic for the DOE to expect the private sector to take over many unfinished coal research projects that will be terminated under the President's FY 1983 budget request. For some program areas, research progress has not yet reached milestones which would permit the private sector to adequately assess the technical risks. And, for those few projects which have reached precommercialization status and for which the marketplace suggests a viable business opportunity, the available decision-making time for private companies or consortia may be too brief. It takes time for a company to conduct the necessary technology and market assessments and secure corporate approval and obtain capital budgets. Under DOE's FY 1983 rescission timetable, federal funding will soon be terminated for many multi-year projects. Consequently, dedicated research facilities will be closed and technical teams disbanded. Once these moves have been taken, it is unlikely that a project can be resurrected because of the additional costs involved.

It is fallacious for DOE to suggest that failure of the private sector to pick up projects which will be terminated by the FY 1983 budget is proof that the federal effort was misplaced in the first place and distorting the marketplace. Since current market conditions affect the timing of new corporate ventures, it is unrealistic to conclude that the industry's reticence to move forward in these difficult economic times is an indictment of the usefulness of the technologies scheduled for termination. In the past, many federal coal research accomplishments have been picked up in due time by industry and developed into commercial products or uses.

Coal Research Priorities

The specific coal technologies supported by the National Coal Association in the past and which continue to be high on our priority list because they complement private sector research efforts are as follows: (1) innovative extraction technologies which significantly reduce health and safety hazards to mine workers, and yet offer improved productivity; (2) coal cleaning and processing systems which reduce sulfur content, ash minerals and other undesirable trace elements in the coal prior to burning; (3) combustion systems that produce environmentally benign solid and gaseous waste products; and (4) synfuel products using conversion processes that can be environmentally controlled to protect the health and the welfare of plant workers and the local communities. The continuing need for long-term, high risk research in these areas, some of which have been the cornerstone of DOE's fossil energy program, must be recognized. We believe a valid assessment of the current coal research programs would provide ample justification for the federal government to complete certain short-term projects and continue to fund the high risk, high potential payoff projects at some reasonable level. Any other course of action would be very shortsighted and detrimental to our national interest in preserving as many options as possible to provide clean energy from coal.

Before closing, there is one further matter that we wish to call to the committee's attention. That matter is the urgent need to recombine DOE's coal mining and preparation program with the Bureau of Mines' similar program. In light of reduced budgets and personnel for these programs in both agencies, keeping them separate can no longer be justified. We urge the committee to facilitate, as soon as possible, the transfer of DOE's coal mining and preparation program to the Bureau of Mines. Not only will there be savings in program management, but a stronger program can be forged from the currently fragmented efforts.

Conclusion

In conclusion, the coal industry supports a reasonably funded federal research program because we believe that it is an important ingredient to this nation's ability to accept with confidence our unquestioned long-term dependency on coal. A balanced energy R&D program must include a commitment by our government to promote a technological base for advanced coal mining and use techniques that can be developed into improved commercial products by the private sector.

Towards this end, it is essential that we have a viable federal program with continuity of research effort pursuing high risk technologies to the point where the industry can carry forward and finance promising developments to commercialization. Through this approach, the nation will have the opportunity to use its vast reserves of coal without compromise.

Senator FORD. Thank you, sir.
Mr. Lawrence.

STATEMENT OF GEORGE H. LAWRENCE, PRESIDENT, AMERICAN GAS ASSOCIATION

Mr. LAWRENCE. Mr. Chairman, to echo what Dr. Yancik just mentioned in regard to a balanced research program, we think that there is no panacea in energy whether it be oil, nuclear, coal, or even gas energy. I think to this end the gas related research has made its contrbution to fiscal prudence. The 1981 gas related research budget was in the range of $300 million. That was cut to $120 million.

And now we are proposing, even though it was cut substantially further by the administration, we are proposing what would amount to a further cut of around 15 percent to a total of $104 million in gas related research. We think this particular gas related research is the very epitome of the criteria that the administration itself has laid down.

And that is high risk, high return and long-term projects. In particular, I would like to focus on two major areas, the enhanced gas recovery, the type formation areas where the National Petroleum Council has estimated that new technology can develop an additional 574 trillion cubic feet and when we compare that with the less than 200 trillion cubic feet of crude reserve we now have, we think that is substantial.

When we look at the eastern Devonian potential of as much as 2,000 trillion cubic feet, again, and compare that with our production in the range of 20 trillion cubic feet now, we are talking about virtually unlimited supplies if we can improve our recovery from those sources.

Then when we get into the truly more exotic, virtually unlimited categories, of geopressured methane of gas hydrates, of abiogenic, research breakthroughs those can truly make a dramatic energy contribution.

In the area of improved coal gasification techniques, this was cut very severely to something like $14 million and we think a minimum of $45 million is needed, particularly where we can focus on the eastern coals and also on in situ coal gasification, where, again, there are huge potential.

I will kind of pass over our numbers that are very important in the fuel cell technology and solar buyer mass and conservation, because I am sure Mr. Podolny and Mr. Webb will focus on those.

Let me add an additional point here on an LNG safety facility, which is funded at zero amount now and we are proposing some $5 million, of which about $2 million is really devoted to summarizing longstanding LNG safety research that has been conducted in southern California and putting together the results of several years of effort.

The additional $3 million we would propose to be recovered by user fees from all different types of fuels but particularly for LNG. We think a lot of the safety tests to date show that LNG has met the safety standards. But we continue to need to have that confirmed by the federal government with the objectivity that would go with it.

So in conclusion, Mr. Chairmam, again, a balanced research, a gas related research is bearing its share of fiscal prudence in everyone of these categories and our minimum amount of $104 million fits on all squares of the administration's own criteria of what long-term research should be devoted to.

Thank you.

[The prepared statement of Mr. Lawrence follows:]

STATEMENT OF
GEORGE H. LAWRENCE, PRESIDENT
AMERICAN GAS ASSOCIATION
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE
ON THE FY 1983 DOE BUDGET
APRIL 26, 1982

Introduction

Mr. Chairman and Members of the Subcommittee:

On behalf of the American Gas Association, which represents nearly 300 natural gas distribution and transmission companies serving over 160 million U.S. consumers in all 50 states, I am pleased to provide you with our industry's views on the Department of Energy's FY 1983 budget.

Natural gas currently provides about 27% of the energy consumed in the U.S. Gas is used in about 55% of all residential and commercial establishments in the U.S., and provides about 40% of the energy consumed by U.S. industry and agriculture. More gas is produced domestically than any other fuel, and gas provides two and one-half times as much end use energy to consumers as electricity.

It is important to understand that no sector of the economy is harder hit by inflation than the utility industry. Therefore, A.G.A. is firmly committed to the budgetary goals expressed by the Administration and by Congress; that is, reducing inflation, revitalizing the economy, and reducing the federal deficit to the extent possible. The proposed cuts in the fossil energy research and budget is not, however, an appropriate means to reach these goals. While we recognize that this is a frequently heard statement on Capitol Hill, we believe there are compelling reasons, consistent with sound national energy policy, why this is so.

Funding Criteria

A.G.A. agrees with the Administration that the federal government should fund only those projects that are high-risk, long-term, and have high potential payoffs. We do not share the Administration's apparent belief that only nuclear programs fit within those criteria.

A.G.A. also agrees with the Administration that the federal government should not fund projects that would otherwise be funded by the private sector. However, that criteria does not justify the near-elimination of the fossil energy research budget. Much fossil energy research -- particularly the gas-related research -- cannot be performed exclusively by the private sector for a number of reasons.

First, many valid high-risk, term projects will not be undertaken by any party -- including any gas utility -- without some government assistance. Advanced gasifiers to convert eastern "caking" coals into gas, new technologies to convert biomass to gas, and all end-use conservation research are projects of little interest to oil and gas producing companies. Those companies are primarily interested in technologies which will increase production --

not reduce consumption or develop substitutes. The long-term research necessary to develop western tight sands and eastern Devonian shale resources fully will not be undertaken by gas producers -- especially in light of the fact that a test well cannot usually be worked-over into a production well. Producing companies, in their legitimate self-interest, will be primarily interested in how much production can be obtained in the near-term using current or near-term technology. More exotic technologies needed to develop abiogenic methane and geopressured methane resources are even less likely to be developed by anyone other than the government.

Second, the gas utility industry lacks the financial resources to conduct long-term, high-risk research. Gas industry funded organizations such as the Gas Research Institute (GRI) and the Institute for Gas Technology (IGT) are increasing their commitment to research as quickly as feasible in order to take responsibility for near-term projects. It is difficult for gas utilities to fund long-range, high-risk research directly. As DOE's Energy Research Advisory Board (ERAB) stated in its Federal Energy R&D Priorities, November 1981, "Both these regulated industries (the gas and electric utility industries) have weak incentives to spend on R&D. If successful, the benefits go to ratepayers; if unsuccessful, the expenditures may be disallowed as 'imprudent'." In addition, many states have not given utilities adequate rates of return in the past. As a result, many gas utilities are in no position to fund long-term, high-risk research projects.

Finally, the gas utility industry will need to dedicate its financial resources to more near-term supply sources and to construction and maintenance of pipelines, mains and auxiliary utility facilities. A recent A.G.A. analysis, "A Forecast of Capital Requirements of the U.S. Gas Utility Industry to the Year 2000: 1982 Update," January 6, 1982 shows that the gas utility industry will require $481.6 billion (1982 dollars) between 1982 and the year 2000. About $130 billion will be used for traditional construction and maintenance activities. The remaining $352 billion will be necessary to develop new gas supplies including Alaskan gas, coal gas, and unconventional gas reservoirs. This requirement is over and above investments likely to be made by traditional oil and gas producers. Obtaining these needed funds will be nearly impossible without government research to prove technological feasibility. There is no "slack" in the system allowing gas utility funding for long-term, high-risk research.

Supply Benefits of Improved Technology

Policy makers have become increasingly aware that the supply outlook for natural gas is very good. In the short term, we have had a situation where artificial demand restraints and NGPA production incentives created a gas supply "bubble" resulting in gas that is available but cannot be sold in some parts of the country. In the long term, the A.G.A. Gas Supply Committee study released in 1980 and updated recently showed the great potential of natural gas to help solve our energy problems.

The A.G.A. Gas Supply Committee, made up of a broad representation of gas industry leaders, undertook a comprehensive assessment of the outlook for conventional and supplemental sources of gas energy to the year 2000. Table 1, developed by the Committee, shows that, while most gas supply estimates are subject to some variation, the largest areas of uncertainty in supply estimates are for the tight formations, coal gasification and nonconventional categories such as biomass conversion to gas, coal seam methane, and geopressured gas. This uncertainty is due to the greater need for technology advancement if these areas are to achieve their high potential.

TABLE 1

GAS SUPPLY -- 2000 (in Tcf)

Supply Sources	Self Sufficiency	World Conventional Gas Emphasis
Lower 48	13-14	12-14
SNG	0.3	0.1
Alaska	2.8	2.8
Canada	1.0	2.0
Mexico	0.1	2.0
LNG	0.7	2.5
Coal Gas	2.7	1.3-2.5
Tight Formations	1.2-3.0	1.2-3.0
Nonconventional	1.0-2.5	1.0-2.5
Totals	22.8-27.1	24.9-31.4

The key point to be recognized in the above chart is that the difference between high and low technology development of tight formations, coal gas and nonconventional sources is on the order of 5 Tcf. It is also interesting to note that 5 Tcf is equivalent to nearly 2.5 million barrels of oil per day.

Because it is difficult for the gas utility industry to fund long-range, high-risk research for regulatory and fiscal reasons, A.G.A. believes that achievement of the supply goal of 31 Tcf -- and the concommitant benefits -- is conditioned on the government financing a part of the long-term, high-risk research.

The Need for a Balanced Research Program

History is replete with examples of the dangers of relying on a single source for any valuable commodity. At the present time, the U.S. produces natural gas, coal and oil at a reasonably well-balanced level: according to DOE's Monthly Energy Review, February 1982, production in 1981 of dry natural gas was 19.978 quadrillion Btus (quads), coal was 18.253 quads, and oil was 18.125. By contrast, nuclear electric power was only 2.908 quads. It should be noted that our consumption of energy is not so well-balanced: petroleum consumption in 1981 was 32 quads compared with 20 quads of natural gas and 16 quads of coal. Lifting federally-imposed restraints on gas use, promoting coal gasification and natural gas fueled vehicles, and developing better, more efficient end-use equipment could result in a better balance of consumption. Such a balance could eliminate the need for oil imports.

Different analysts have differing views on the fuel supply mix that the U.S. will have by the year 2000 and beyond. One thread in common, however, runs through all analyses: fossil fuels will remain the predominant source of energy. The analysts differ only in their perception of the relative minority shares to be supplied by nuclear, solar, wind, ethanol and other "alternative" supplies.

Given our nation's dependence on fossil energy, now and in the foreseeable future, it is bad public policy to eliminate the fossil energy research program.

Although A.G.A. supports reductions in federal spending, it does not support the drastic and unbalanced reduction in the fossil energy share of the R&D budget. Only the fossil and renewable energy areas have suffered a reduced share of the total R&D budget while over the same period, all other areas have remained constant or increased. (See exhibit attached). Specifically, fossil research has been slashed from 12% of the total in 1981 -- a share roughly equivalent to that of nuclear fission programs in 1981 -- to a clearly insufficient 1% allocation proposed in FY 1983. There are many good gas-related projects that are worthy of an increased share of Federal support.

Recommended Gas-Related Research Projects

A.G.A. recommendations, developed through deliberations by our Technology Committee and in consultation with the Gas Research Institute and the Institute of Gas Technology, reflect what we believe to be the minimum level of funding consistent with the ideal of a balanced energy research program. Funds are recommended only for projects with high potential and commensurate high risks.

A. Unconventional Natural Gas: $32 million

- Estimates of the gas resource trapped in the Western tight sands of the Rockies, Northern Great Plains and Southwest, in lenticular and blanket formations, range from 400 to 1000 Tcf. While 0.5 Tcf/year is currently being produced, substantial new production is dependent on the development of advanced technology. Almost 90 percent of the resource base is in lenticular formations which cannot be produced with current technology. Production estimates in the year 2000, given only existing technology, will probably be less than 3 Tcf/year while development of advanced technologies could increase production to approximately 6 Tcf/year.

- Devonian shales located in the Appalachian, Michigan and Illinois basins contain a DOE estimated 200 to 2000 Tcf of gas in-place. In addition to the 0.1 Tcf/year produced commercially from Devonian shale today, approximately 200 new wells were drilled in 1980. Based on existing technology only, the estimated production from Devonian shale formations would be less than 0.8 Tcf/year by the year 2000. This production level could double through the development of advanced technologies.

- Geopressured aquifers[1] of the Gulf Coast may contain between 42 and 2000 Tcf of recoverable gas dissolved in saturated brine. Significant uncertainties must be addressed in a well-conceived and coordinated research and development program to examine type and size of the resource, long-term production rates, impact of off-set wells, cost of gas production and environmental impacts. Until these and other questions are answered through an expanded research and development program, it is impossible to properly ascertain the long-range energy contribution of geopressured aquifers.

- Advanced unconventionals such as gas hydrates and abiogenic methane truly represent a high potential payoff. Gas hydrates are an ice-like mixture of gas and water in which gas molecules are trapped by a framework or "cage" of water molecules. Abiogenic methane is gas that is not biologic in origin. Some scientists believe vast quantities of such gas could be found in extremely deep reservoirs.

  At the present time, the resource base of gas within these reservoirs is poorly defined and theoretical. The amount of gas which is recoverable is even more speculative. No one is predicting a near-term breakthrough, but some observers believe that these potential sources of gas could some day produce virtually unlimited amounts of energy. Government support is needed to increase knowledge of the resource base and reservoir mechanics for these advanced unconventional sources. Only with more knowledge will we gain an understanding of costs and potential benefits of developing these sources.

- In-situ coal gasification has the potential to significantly expand economic attractiveness of coal seams which are currently unmineable. A variety of technical questions must be answered before significant amounts of gas can be produced through in-situ gasification processes.

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[1] The geopressured methane program's budget is not subject to this Subcommittee's jurisdiction.

In order to convert these tremendous resource bases into viable producing reservoirs, advanced technologies need to be developed.

Ongoing DOE research in tight sands is focused on the Multi-well drilling program in Garfield County, Colorado. The proposed budget, intended to bring this experiment "to a successful conclusion,"[2] will instead end the experiment prematurely. Three test wells, as originally planned, would provide a three-dimensional picture of the extent to which fracturing occurs throughout multi-lens geophysical areas, thereby boosting the prospects for developing tight sands reservoirs. Approximately $11 million has been spent so far in drilling the first two of these wells.

It is important to recognize that the private sector is doing considerable research in the area of tight blanket sands. The Multi-well Experiment, however, is examining tight lenticular sands -- formations shaped somewhat like lenses where the pay zone may extend a thousand feet measured vertically, but, horizontally, is not as large as conventional or blanket sands. The private sector has the means to perform the near-term research necessary to develop blanket sands, but the long-range, high-risk technology necessary to develop lenticular tight sand reservoirs -- that contain 90 percent of the resource -- must be government-sponsored.

Such sponsorship is justified. The National Petroleum Council (NPC) estimates that with advanced technology tight sands may hold 574 Tcf of recoverable reserves -- 170 Tcf more than could be recovered under NPC's most optimistic current technology scenario and nearly three times our current level of reserves.

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[2] Congressional Budget Request FY1983, U.S. Department of Commerce, Energy Research and Technology Administration, Vol. 5, pg. 113.

The proposed budget also eliminates the Devonian shale program. DOE estimates that as much as 2,000 Tcf of gas may be located in the shales of the Appalachian basin. Funds expended up to this point have been used to develop the resource base estimate. Now that we have a reasonably good understanding of how large the resource base is, it is foolish to eliminate the program until we have a better understanding of how to produce that gas. Estimates made by the A.G.A. Gas Supply Committee -- in conjunction with GRI -- indicate that the level of recoverable Devonian shale gas is at least as dependent on advanced technology as it is on price. Judiciously funded research would provide a doubling in recoverable resources without substantial price impacts. The Eastern Mineback experiment should be funded so as to increase our knowledge of fracturing shale and producing gas.

The bulk of the funds needed to see these two vital experiments to completion would be expended over the next few years to drill or mine at the site. Relatively small levels of funding will be needed after that in order to test various fracturing and other production enhancement techniques.

A.G.A. also recommends that continued research be performed to research and develop methods for production of abiogenic methane, methane from coal seams, and gas hydrate resources. The existence and location of the abiogenic methane resource must be confirmed in order to determine a method of recovery. Extraction and production methods for coal seam methane based on increasing the permeability of the coal must be established. Fundamental laboratory work on gas hydrate formations should begin in FY 1983. Funding levels in these areas should be sufficient to ensure that ongoing programs maintain continuity. Only with more knowledge will we gain an understanding of costs and potential benefits of developing these sources.

B. Coal Gasification : $45 million

The production of synthetic fuels will be a major contributor to the long term energy supply. By the year 2000, synthetic fuels are forecasted to supply 3 to 5 million BOE/day. Coal gasification and indirect coal liquefaction will be the major synthetic fuels, accounting for over half of this total. Nuclear energy, by contrast, will account for about 3 to 4 million BOE/day by the 2000 in spite of its current limited role (1.4 million BOE/day) and massive federal support.

The United States is estimated to have coal reserves of some 438 billion tons, containing 10,000 quads, one-half of which can be recovered under present technical and economic conditions. This abundant domestic resource can be converted to environmentally benign methane which can be used to replace imported oil in virtually every industrial stationary use.

While first-generation surface coal gasification is a proven technology, advanced gasifiers that can use agglomerating high-ash coals require further development. Such technology would allow gasification plants to be sited in areas hard-hit by the current recession such as: Illinois, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia. Because direct combustion of much of this eastern coal is environmentally prohibited, gasification is the best way to encourage production, spur job creation, and provide these states with a usable domestic fuel. A.G.A. projects that as much as 2.7 quads could be produced by surface coal gasification by the year 2000.

About 220 billion tons of coal is mineable under present technical and economic conditions. An estimated 3,800 billion tons is not currently mineable. A substantial amount of this resource base could be suitable for in-situ gasification. DOE research on steeply-dipping beds has attracted wide interest within both the coal and the gas industry. Successful DOE research to improve reliability and efficiency of the process could potentially "quadruple U.S. coal reserves while providing fuels at potentially lower costs and with less adverse environmental impacts than other synthetic fuel options."[3] Despite this glowing tribute to the potential of in-situ coal gasification, the proposed budget recommends termination of all activities except for legally required environmental monitoring.

C. Fuel Cells, Gas Fired Heat Pump, and Renewable Resources: $27 million

A.G.A. believes that fuel cells and advanced gas prime movers, including heat pumps, offer significant advantages for energy conservation. Residential, commercial, and industrial customers have made great progress in conserving energy, but much of the "easy" conservation such as insulation and thermostat adjustments has already been made. The next step must be development of more efficient equipment. Development of gas-fired fuel cell technology offers industrial and large commercial customers a significant savings in generating heat and on-site electricity Advanced prime movers that can provide both heat and air-conditioning offer hope to the residential customer -- currently facing increasing electric and gas fuel bills.

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[3] Ibid, page 62.

A.G.A. also believes that biomass may be an important supplemental source of methane in the future. A balanced energy program should fund biomass-to-gas programs at a level sufficient to keep research progressing. To the extent that there is a research breakthrough allowing economic conversion of biomass to gas, this represents an inexhaustible, renewable supply source.

D. Safety Related Research: $5.5 million

We have been most disappointed to learn of the DOE Office of Environmental Protection Safety and Emergency Preparedness plans to terminate funding of LNG safety research underway since 1977. This action is not consistent with the need for a broader energy supply mix and safety outlook in the budget.

The Department of Energy has funded LNG safety research in a program that started in 1977 and was to extend through the mid-1980's. Large amounts of data have been collected but not analyzed or reported. In the absence of program continuation, A.G.A. feels that the first priority should be the preservation, analysis and reporting of the results obtained to date and we, therefore, recommend that $2.0 million be authorized for this purpose.

A.G.A. also suggests that Congressional consideration be given to funding a national safety test site at an appropriate location such as Frenchman Flats, Nevada, that could be used for government and private sector research. We recommend that $3 million be authorized for construction of this facility. Costs could be recouped through a system of user fees. This recommendation is particularly cost effective because this facility could take advantage of surplus and already used equipment at present test sites.

The Methane Transportation Research, Development and Demonstration Act of 1980 (P.L. 96-512) authorized a total of $13 million to be spent over 5 years for research and demonstration programs. This Act was passed to advance the use of natural gas as a vehicle fuel in order to reap the benefits of displacing gasoline refined from imported oil. While this program had no funds appropriated for it last year, $500,000 from a fund of $4 million in the Alternative Fuels Program budget was specifically earmarked to implement the research portion of the Act. These funds have been used to prepare research proposals to: 1) Research and test concepts for lighter, reinforced storage tanks to reduce weight and increase range; and 2) examine the maximum efficiency achievable from a dedicated natural gas powered vehicle. If a similar amount were appropriated this year, important research could begin to resolve safety and emission issues and identify and remove institutional barriers. A.G.A. is firmly convinced that natural gas as a fuel is both safer and cleaner than gasoline or diesel fuels. We recognize, however, that no number of private industry studies to that effect can equal the impact on the public's perceptions of a single well-documented government study. The perception of lack of safety is the prime institutional barrier which must be removed. We, therefore, recommend that $500,000 be earmarked for FY 1983 for natural gas powered vehicle safety and emissions research.

Conclusion

It is difficult for gas utilities to fund high-risk, long-term research projects directly. A pattern of inadequate regulatory decisions has begun to impair the financial standing of gas utilities. Over the next twenty years, the gas industry will have to raise approximately $480 billion (in 1982 dollars) to finance gas supply, transportation, and conservation projects. These funds will be spent primarily on construction to enable the gas utility industry to meet demand. Research and development activities are, however, an integral part of the full development of domestic gas resources and these activities should be strongly supported by Congress, DOE, and industry.

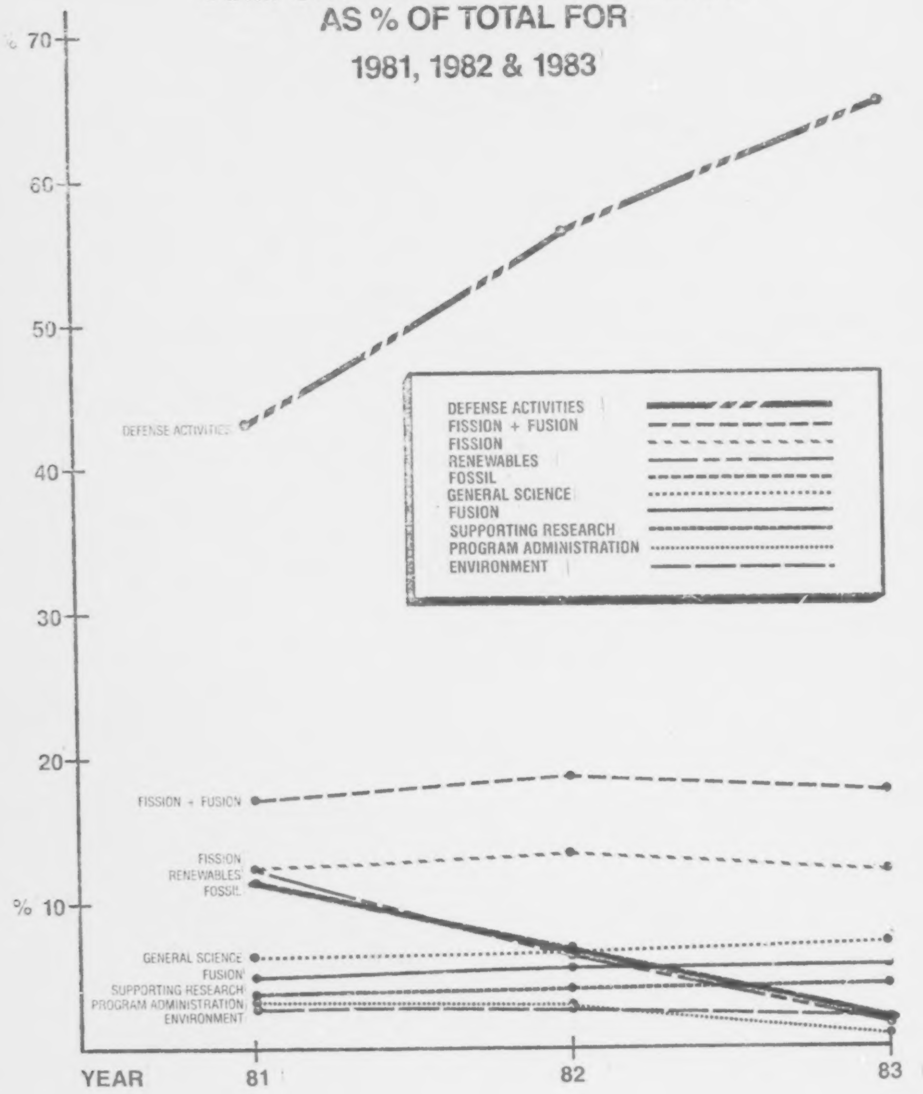
Even though gas provides 2 1/2 times the energy to end users as electricity, the proposed FY 1983 budget slashes gas research programs. Of even greater importance, fossil energy will continue to play the major role in our nation's energy supply, yet the proposed budget reduces fossil energy research to 1% of the DOE budget. A balanced energy research program to allow production and use of fossil energy in an efficient and environmentally sound manner is, therefore, in the national interest.

Gas related programs within such a program should be funded at least at a minimum of $109.5 million. Research priorities should include: $32 million for unconventional natural gas reservoirs such as tight sands, Devonian shale, hydrates, abiogenic methane, and geopressured zones; $45 million for surface and in-situ coal gasification; $27 million for fuel cells, advanced gas prime movers, and biomass conversion to gas; $5 million for LNG Safety research; and $500,000 for natural gas powered vehicle safety and emissions research.

The key concept behind the need for R&D in all these areas is that we cannot mortgage the next 20 or 30 years while waiting for technology to develop in areas such as nuclear fusion. The price incentives currently in place are sufficiently high enough to allow exploitation of conventional, and unconventional resources with current technology. It has been shown, however, that the commercial recovery of these resources are as dependent on improved technology as on price. It would be short-sighted to put undue emphasis on price incentives and ignore the potential of improved technology to allow greater recovery of these resources.

Gas is an ideal bridge fuel that will enable us to enter the 21st century with adequate domestic energy sources. The ability of the gas industry to meet the nation's energy needs in the 21st century will depend substantially, however, on whether R&D work is begun now.

COMPONENTS OF DOE R&D BUDGET AS % OF TOTAL FOR 1981, 1982 & 1983



Senator FORD. Thank you. Dr. Lee.

STATEMENT OF DR. BERNARD S. LEE, PRESIDENT, INSTITUTE OF GAS TECHNOLOGY

Dr. LEE. Thank you, Mr. Chairman. I am Bernard Lee, president of the Institute of Gas Technology, a not-for-profit organization that does R&D in the energy field and conducts energy-related education. We are concerned as doers of energy R&D with the continuity of effort from laboratory studies to commercial scale demonstration to a fully established commercial and technical feasibility.

I strongly support the participation by the private sector, but we are equally concerned that Government support must be there to provide the necessary support to get technology to the commercial demonstration stage, an effort which is greater than what industry can take on by itself, even with tax incentives, loan guarantees, and price guarantees.

We are also concerned that reduced support of energy technology development for even a few years would cause a gap in energy technology work, through the dissolving of centers of technical expertise and dispersal of trained personnel.

New technology is necessary to meet future energy needs. This cannot be handled by turning energy R&D on and off like a spigot, in response to short-term fluctuations in the world energy supply in a crisis over which we have little control. I am concerned also that the stability of the world oil market is fragile. As we all know, it can be shattered overnight by people in the Middle East.

The continuing war between Iran and Iraq, the export of Khomeni brand of Islams and the menacing Soviet presence are all too well known to us. Each is a short fuse that could set off major oil disruptions. We feel that the current oil glut should be regarded as a temporary respite, a time for us to deploy alternatives.

It took an oil surplus of only 2 million barrels per day, less than 1½ percent of the world annual energy consumption to transform the world oil market from a seller's to a buyer's market and we feel the reverse could happen very easily. Therefore, insuring a commercial scale capability for an adequate and secure energy supply outweighs all of the considerations. Energy is so vital and so essential to the maintaining of the United States-Soviet power balance and the economic stability of the world that the Nation must place the same priority on energy as it does on defense. National policy must focus on energy, because the private sector could never factor national needs into investment decisions.

As far as the R&D program is concerned, we fully support the $104 million long-term R&D budget for fiscal year 1983 recommended by the national gas industry, which Mr. Lawrence has touched on. I as an R&D performer would like to address a few specific areas in energy supply, conservation, solar R&D of which we at IGT are actually engaged.

In the unconventional gasfield, we have been working on developing accurate methods for developing natural, for measuring natural gas produced with fuel pressurized well water; $16 million is recommended to obtain additional basic data to assess the ability of fuel pressurized aquifiers to produce gas in excess of solubility and reservoir brime.

IGT has been working on defining a standard for measuring the permeability of tight sand formations for DOE and the measuring of behavior of the reservoir volume as gas is produced. To obtain additional tight sand core samples, $6 million is recommended for laboratory studies; $4 million in the area of gas hydrates, abiogenic methane, and coal seam natural gas for the very long term.

In coal gasification, based on IGT's long history of R&D in its field, we recommend specifically $4 million to continue basic support studies at IGT, which will include catalysts, understanding of ash behavior, analysis of fluidized-bed systems and improved waste processing, and $1 million to continue the coal conversion system and technical data book by compiling, evaluating, and correlating the necessary design data for coal conversion and utilization.

As a pioneer in developing processes to utilize our Nation's peat resources $3 million is recommended to continue work on peat harvesting, dewatering by wet carbonization, resource and environmental assessment and $7 million for the development of the pressurized ash-agglomerating gasifier applicable to hydrogen production, combine cycle powerplants and methanol synthesis.

In fuel cell, we as the leader in molten-carbonate fuel cell technology recommend $7 million to continue this development, including $3 million for fundamental research to determine performance and life characteristics for fuel cell materials as well as multifuel capability research; $3 million for solid oxide electrolyte technology development to do laboratory testing to solve high temperature material problems.

In biomass $1 million to operate the PDU of the renugas process to convert forest and biomass materials to fuel and $2 million for growth and harvesting development in the long-term genetic research.

In the area of hydrogen, this is a long-term fuel that can be produced with base-load power stations, stored and later utilized for power generation or for clean fuel, and $3 million is recommended to sustain an effort in thermochemical research, to convert solar energy to hydrogen and to do the fundamental studies of catalytic combustion of hydrogen.

And, finally, in addition to all of the above, for onsite commercial or industrial usage of solar energy, thermal energy storage with the use of molten salts can be applied to processes that require high levels of periodic thermal energy demand, such as is needed in the kilns of the brick, clay, ceramic, and cement industries.

We recommend $8.5 million to continue the molten salts storage R&D to address the applications, operating requirements and storage media configurations.

Mr. Chairman, the list may seem long, but I only point out the many holes that seem to be in the administration's energy R&D program, especially in the non-nuclear. Thank you very much.

[The prepared statement of Dr. Lee follows:]

Statement by Bernard S. Lee, President
Institute of Gas Technology
Before the Senate Committee on Energy and Natural Resources
Subcommittee on Energy Research and Development
Hearings on Department of Energy Budget Authorizations

April 26, 1982

Mr. Chairman and Members of the Subcommittee:

My name is Bernard S. Lee. I am President of the Institute of Gas Technology, a not-for-profit energy R&D organization affiliated with Illinois Institute of Technology in Chicago. IGT has specialized in energy RD&D work and energy-related education programs for 40 years. I will provide you today with my assessment of the continuing energy RD&D needs of the nation.

In past years IGT appeared before Congress to offer progress reports on various research projects in which we were engaged. During the previous Administration our work on synthetic fuels technology received much encouragement. Congress strongly supported this energy technology development in response to the oil supply disruptions and price spikes in the 1970's.

Now, however, government energy policy is directed toward funding long-term high-risk research, with the expectation that private industry will start funding much energy RD&D that was formerly carried out by the Department of Energy. Government involvement will focus on the areas of basic science and applied research, leading toward, and perhaps including proof-of-concept. Process development and demonstration, which are the necessary precursors of commercialization, would be left to the private sector.

Our concern is for the preservation of the continuity of effort from laboratory or bench-scale through the larger process development units, pilot plants and then to the size required to assess commercial and technological feasibility. While I strongly support participation by private enterprise to the maximum extent possible in the development of new energy technologies, I believe we must be realistic about the need for government support of high-risk new technologies where the cost to get to commercial demonstration (even with tax incentives, loan guarantees, and price guarantees) is so high that few, if any, major companies can support such efforts.

We are also concerned that with diminished government support for energy research and development, especially development, an "energy technology gap" will be created. Reduced support of energy technology development for even a few years will surely result in the dissolution of centers of technical capability and the dispersal of highly qualified technical personnel to other endeavors. In that case, an entire new generation of technical and scientific personnel will have to be trained again and given sufficient practical experience before it can contribute to energy technology development programs. In short, an "energy technology gap" of at least a decade could result from the current, and in my view, short sighted, thrust of the government's energy programs. The new technology necessary to meet future energy needs cannot be provided by turning energy RD&D on and off like a faucet in response to short-term fluctuations in world energy supplies and prices over which we have little, if any, control.

Although for the past two years the energy picture began to look brighter, this was due to the economic slow-down, the continued substitution of domestically produced energy for imported oil, and conservation due to the improvements in the efficiency of energy use. However, it would be foolish to allow these positive trends to lull us into complacency. First, demand reduction will not continue at the same rapid pace, because the more easily accomplished conservation measures have already been implemented. Further and sustained improvements will become more difficult. Second, although many users were able to substitute coal for oil, the next increment of coal substitution for imported oil will be more difficult and costly. Most importantly, any economic upturn, which is anticipated sometime this year, will immediately trigger increased energy demand.

On the supply side, despite recent heightened activity in oil and gas production, most of the drilling in the U.S. has been to increase production of established reservoirs rather than for new exploration. Although the decline in our oil reserves has leveled off, the stabilization of reserves estimates is due largely to a revision of estimates of previously discovered reserves. New discoveries were equivalent to only 29% of production in 1980. Although, undoubtedly, we do have substantial amounts of oil yet to be found, it is generally accepted that the potential for large-scale new discoveries is limited.

The stability of the present world oil market is itself a fragile thing that could be shattered overnight by any upheaval in the Middle East. Iran remains in the throes of political change and is still at war with Iraq, a war which is highly divisive to the Persian Gulf nations. Further, one of the main motivations for OPEC's moderate attitude toward price is fear -- fear that the West will finally develop alternative energy sources that could, if not put it out of business, at least act as a constraint on its control of pricing. Sheik Yamani, the Saudi oil minister, is on record saying that "If we force the West to invest heavily in finding alternative sources of energy, they will. This would take no more than seven years and would result in reducing (The West's) dependence on oil as a source of energy to a point that would jeopardize Saudi Arabia's interest."

The current world oil "glut" should be regarded as a temporary respite, a breathing spell that gives us time to develop alternatives for the day when imported oil will not be available under acceptable conditions. We should keep in mind that it took an oil surplus of only 2 million barrels a day, less than 1.5% of the world's annual energy consumption, to transform the world oil market from a seller's to a buyer's market in 1981. The reverse could easily happen. The question that must be answered is how can we maintain secure and dependable energy supplies, both as an individual nation and as the leader of the free world. We must also recognize that we and our allies are on the downward slope of a rather severe recession, and another major upset in the world's oil supplies could have a much more severe impact than the upsets of 1973 and 1978.

I have always advocated letting free-market forces work. However, our free-market economy has never been totally free. We have a long tradition of peace-time public investment in those areas vital to our well-being, security and prestige as a nation. The national highway system, support for the farm industry, space programs and defense are national decisions which transcend the free market and must be undertaken by society as a whole.

Energy is so vital and so central to the power balance between the U.S. and U.S.S.R. and the economic stability of the world, that the Administration must place the same priority on energy as it does on defense.

Therefore, insuring a commercial-scale capability for an adequate and secure energy supply outweighs all other considerations. National policy must establish energy as a high priority because the private sector can never factor national needs into investment decisions.

We fully support the $104 million minimum long-term gas-related federal R&D Budget for FY '83 recommended by the gas industry. The following are specific R&D program elements in which IGT is actively engaged.

Unconventional Gas

During the past year IGT continued research on unconventional gas including field projects, laboratory research and analytical studies. The principal areas of work were determination of geopressured/geothermal aquifer gas content and production prospects, laboratory characterization of reservoir rock and stimulation procedures for gas production from tight sands and coal seams.

- IGT developed and utilized an accurate method of measuring natural gas produced with geopressured well water. Use of this method demonstrated higher gas production than anticipated in previous theoretical gas production studies. In one case an abandoned well, which had been judged a dry hole from conventional test procedures, produced so much natural gas that it is still in commercial production 17 months later.

  In FY'83, $16 million will be required to obtain additional basic technical information needed to assess the portion of geopressured aquifers capable of producing otherwise undiscoverable gas in excess of solubility in reservoir brine. Tests would be conducted on wells originally drilled in search of geothermal energy. Test equipment already in place at the geothermal well sites would be augmented with the unique instrumentation and analytical procedures developed by IGT.

- IGT has established the definitive DOE standard method of determining the permeability of tight sand formations and how the reservoir volume of tight formations changes as gas is withdrawn during production. Continuing basic work is needed on means to answer such questions as gas content of the sand adjacent to the well bore, how the gas flows through the sand and the size of the lens or reservoir. It is anticipated that the answers to these questions will increase the recoverable resource by 70-90 trillion cubic feet. We recommend a $6 million funding level to permit tight sand core sample removal and laboratory study. Coordination between laboratory operations, well drilling and well testing will be essential.

- $4 million is needed to permit further research on advanced unconventional natural gas resources including gas hydrates, abiogenic methane and coal seam natural gas. Gas hydrates are solid compounds of methane and water which form under conditions of low temperature and high pressure. Gas hydrates have been found in arctic regions of the world and enormous quantities are believed to be present in sediments in the deep ocean bottom. Abiogenic methane is natural gas from non-biological origins. It has been hypothesized that much abiogenic gas was trapped in the earth when it condensed from the nebula surrounding the sun billions of years ago. Both gas hydrates and abiogenic methane are very long-term, high-risk, possible future sources of gas; but we need to know more about the trapping and transport characteristics in source rock in order to evaluate methods of recovery.

IGT's research on gas production from coal seams has revealed that conventional well completion procedures, such as hydraulic fracturing, are much less effective than in conventional gas reservoirs due to fundamental differences between coal and the sandstone or limestone rock in conventional reservoirs. As with hydrates and abiogenic gas, fundamental research on gas trapping and transport in coal is needed for devising more effective well completion procedures.

Coal Gasification

As you know, IGT has a long history of research and development in coal gasification. We recommend the following actions, consistent with the Administration's policy of long-range research to improve the efficiency of coal gasification processes.

- Continuation of essential work by IGT is recommended in the development of improved catalysts to enhance the efficiency of coal gasification processes, studies of coal ash behavior to improve coal utilization and gasifier operation, studies of fluidized-bed systems for improving coal gasification processes and investigation of improved processing techniques for product and waste streams. These basic research and support studies would require $4 million in FY'83.

- Since 1974, IGT has been compiling, evaluating and correlating the necessary design data to be applied to numerous coal conversion and utilization projects — the Coal Conversion Systems Technical Data Book. These data are presented in forms needed by engineers and scientists engaged in projects or developments within the emerging synthetic fuels industry. As such, the Data Book helps foster the transfer of government-supported technology development to the point of commercial application by private industry. $1 million to continue the Data Book effort is necessary to enhance the ability of industry to undertake major gasification projects.

- As a pioneer in developing processes to utilize our nation's large peat resources, the peat gasification program at IGT achieved major milestones during the past year. The HYGAS plant has been successfully modified for operation on peat; high-pressure lockhopper operation for feeding of peat has been demonstrated; carbon conversions in the PEATGAS process have exceeded 90% with high yields of methane.

  $3 million is needed to continue work on peat dewatering, harvesting, resource and environmental assessment. Further development of wet carbonization of peat is also included to provide suitable feedstocks for either gasification, liquefaction or direct combustion of peat.

- $7 million is needed for the development of the pressurized ash-agglomerating gasifier which could have broad application in such diverse areas as industrial fuel gas production, hydrogen generation for chemical production, combined cycle power plants and methanol synthesis. The ash-agglomerating process, with its superior method of feeding and ash discharge, results in better separation of ash residue, improved carbon conversion (efficiency) and produces a non-leachable ash. These efficiency and environmental considerations are clearly worthy of further experimental development. Of the total, $3 million is for modifying an existing facility and $4 million for operation and preliminary testing.

Fuel Cells

Phosphoric acid fuel cell technology has received sustained government funding to permit it to reach the demonstration phase. It is now important for continued government funding at an accelerated pace for development of the molten carbonate system because of its superior performance and energy conservation potential.

The molten-carbonate fuel cell offers the utility industry a means to generate power from coal at approximately 50% cycle efficiency which is a significant improvement over a conventional steam plant. IGT has invested nearly 500 man years of professional expertise in fuel cell R&D in a twenty year period, and maintains extensive laboratory and development facilities for fuel cells and related fields. As a result, IGT is unique in the U.S. and probably in the world in its combined knowledge and expertise in the areas of fuel cells, coal gasifiers, and gas cleanup systems. Molten carbonate cell technology has been proven by IGT at the single cell level in cell sizes up to one square foot. Some testing of multiple cell stacks containing as many as 20 cells of one square foot area has begun. Future RD&D needs include scaling cell sizes up to the commercial level, further testing and verification of gas manifolding, temperature control and cell configuration, and demonstration of the technology using 5 to 200 cells of the one square foot size. Additional molten carbonate R&D is required to develop improved fuel cell components and fabricate them into prototype stacks to verify system efficiency and production costs.

Japan, as part of its Project Moonlight, is focusing on all facets of fuel cell technology and is committing 11 billion yen (U.S. $50 million) over the next six years. In the U.S., EPRI and GRI are committing their financial resources for fuel cell development primarily in support of near-term (phosphoric acid fuel cell) commercialization. There is no existing fuel cell industry to take on the developmental responsibility and associated risk of the longer-term technology. Therefore, it is essential for the government to provide support until the technology and the industry are both ready for commercialization.

- $7 million is required to continue molten carbonate fuel cell (MCFC) technology development. Of this amount, $3 million should be allocated for fundamental MCFC technology research needed to determine performance and life characteristics for candidate fuel cell materials as well as multifuel capability research. The direct feeding of gaseous or liquid hydrocarbon to the MCFC, using internal reforming, has been tested at IGT and the very promising results indicate such a system could be substantially simpler, with increased power generation efficiency, reduced cost and improved reliability. These R&D activities are necessary for the earliest application of MCFC technology in the industrial and commercial sectors. In order to disseminate information on cell life and performance directly to all potential manufacturers, the use of DOE's existing endurance prototype testing facility and controlled environment facility would be required.
- $3 million is necessary to continue a broad program in third generation solid oxide electrolyte technology. Extensive laboratory testing is necessary to meet the challenging materials problems inherent in a system operating at 1800°F. Laboratory work is needed to find candidate materials to handle the higher temperatures and to determine the life of cell components. These efforts would begin to lower material costs.

Biomass

- With DOE funding, work on IGT RENUGAS process (steam-oxygen gasification of forest and plant biomass materials for fuel) has proceeded from laboratory and bench scale studies to the design and construction of a process development unit (PDU). $1 million is needed to support the operational phase which will provide better understanding of the relationship of biomass feed characteristics to fuel yields and provide the basis for long-term genetic development of feed stock species.

- The production of renewable energy from marine biomass is definitely a long-range supply option. While commercial production of kelp and seaweed is already underway in Japan and China, the methods are very labor-intensive. A more technological approach to growth and harvesting would reduce costs and provide a suitable biomass feedstock for applications in the U.S. Marine biomass production is attractive because it can be done over a much wider area than for land-based biomass, and because marine biomass does not contain lignin and is readily biodegradable.

  Digestion of biomass for energy production takes place in three essential steps: (1) hydrolysis and liquefaction, (2) fermentation to produce hydrogen, carbon dioxide and acetic acid, and (3) methanogenesis — the production of methane from the fermentation products. Through isolation and characterization of the key bacterial populations involved, it may be possible to develop special bacterial inocula to enhance and optimize reaction rates for each step, and to isolate the principal and most effective organisms.

  $2 million in FY'83 would permit continuation of preliminary work to develop a technological approach to growth and harvesting as well as basic genetic engineering research.

Hydrogen

Nuclear heat or electricity, solar or wind energy and other renewable energy sources are not storable like fossil fuels, and long-distance delivery of most renewable energy forms is impractical without conversion to a chemical fuel form. A long-term solution to those problems is hydrogen. It can be produced with base-load (fossil, nuclear and solar) power stations, stored, and later utilized in both conventional (gas turbine) and advanced (fuel cell) electric power peaking generation equipment. Unlike batteries and mechanical storage devices such as flywheels, hydrogen can be stored for long durations without degradation of energy quality.

- However, before hydrogen can be economical as a fuel in the long-term, much advanced technology development is needed. IGT has been a leader in hydrogen research and recommends sustained support in:

  —experimental work on thermochemical conversion of solar energy to hydrogen.

  —fundamental studies of catalytic (flameless) combustion of hydrogen.

  This program should be sustained over at least a five-year period. A first year funding level of $3 million is essential to begin this work.

Storage

In addition to the above, there is a strong need for energy storage R&D to meet large seasonal changes in energy demand. In order to meet the seasonal heating and cooling requirements in the U.S., 18 times more energy is needed in the winter than in the summer. In the Northeastern U.S. this factor increases to 90 times.

One thermochemical method of thermal energy storage (TES) for on-site commercial or industrial usage of solar energy is the use of melted salt or salt mixtures. Work began in March of 1981 at IGT on a three-year project under DOE sponsorship to develop an advanced energy storage system using molten carbonate salts, and applicable to all industrial processes that require high levels of periodic thermal energy demand. Examples are the high temperature batch-operated furnaces and kilns common to the brick, clay, ceramic and cement industries, although the work is not limited to these specific industrial areas. The feasibility of retaining molten carbonate salts in porous oxide ceramics for thermal energy storage has been proven using low-cost materials which exhibit good stability.

A broad-based generic R&D program is required to address the many applications and operating requirements as well as the many possible storage media configurations identified or thought to be possible. After sufficient research and technology development, industrial trade associations, TES user groups with comparable requirements and potential TES system manufacturers could be involved in transferring the technology to the commercial sector.

- The funding requirement in FY'83 for thermal energy storage RD&D based on molten salts is $8.5 million and will permit the following work:
  - Measurement of physical and chemical properies of potential media materials.
  - Optimization of media thermal and physical behaviors within expected operating conditions.
  - Media selection/development to fit application temperatures and operating requirements.
  - Materials compatibility studies addressing media, containment, working fluids and auxiliary components.
  - Mathematical modeling of heat transfer performance and optimum integration into the heat-source/heat-use sequences.

In summary, sustained research and development programs to assure a continuing flow of improvements and innovations, coupled with a growing synfuels industry, would be the most effective insurance the nation can provide against oil-related economic disruption.

Thank you for this opportunity to present my views.

Senator FORD. Your last few words seem to be the most important that you mentioned.

Mr. Webb.

STATEMENT OF DAVID O. WEBB, VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE

Mr. WEBB. Thank you, Mr. Chairman. I am pleased to appear before you today representing the Gas Research Institute to discuss our views on the Department of Energy's fiscal year 1983 budget request and to emphasize the continuing need for Federal support of long-term, high-risk research on supplemental sources of gas and its more efficient use.

The Gas Research Institute is a not-for-profit scientific research organization formed with the gas industry in 1976 to plan, finance, and manage an expanded and fully coordinated gas research development program.

This program is annually reviewed and approved by the Federal Energy Regulatory Commission. GRI supports the basic shift of letting the market govern the development of introduction of new energy sources and technology. We also think that industry funding in the near-term research and the final technology developments prior to introduction of products in the market is proper, since only industry can effectively introduce new products in the marketplace.

Thus far the shift and emphasis outlined in the national energy policy plan is correct. It is such an abrupt change from past Federal energy policy and requires some sort of an orderly transition. The gas industry, we thought, had responded well to the proposed changes in the Federal energy policy by increasing our funding for near-term research significantly in 1982.

In addition to that our board of directors last week approved for GRI to request from the Federal Energy Regulatory Commission a 39-percent increase in our research funding for 1983 contract R&D. This would be an increase from $84 million in 1982 to the level of $117 million in 1983. It should be noted that of the $33 million increase, approximately $29 million is solely for near-term research that previously had been cofunded with the Department of Energy.

Our concern essentially, Senator, is that the budget submitted by the Department of Energy, which essentially eliminates not only fossil energy research, but gas-related research to a level less than $20 million as proposed in 1983, it is consistent with the national energy policy plan, and what it means is that as industry picks up the near-term research, the Federal Government is not proposing to continue the long-term high-risk research, and we are going to have a tremendous void in a few years in our research.

I think there is also a national policy implication in this in that gas currently supplies over one-third of the energy in the industrial market and approximately 15 percent of the energy used to generate electricity, combined markets of approximately 6 million barrels of oil a day equivalent.

This market is primarily captured due to prices. At the current time with gas prices regulated, gas has an advantage and as gas prices rise, unless the technology base is developed, then you are going to see fuel switching in this market back to imported oil, which in turn impacts the long-term stability of the gas market as well as the United States and the energy market.

One other area that I would like to touch on very briefly and that is that we have pursued a program of cofunding with the Department of Energy where appropriate in gas-related R&D. In 1979 we cofunded with the Department of Energy approximately $53 million worth of research, which has grown to a level of $73 million in 1981.

Based on the proposed budget by the Department for 1983, this would be reduced to a level of $6 to $8 million. So even though we are increasing our budget by $33 million, the dropoff in Federal funding is such that the total gas-related research is being reduced by approximately 40 percent under the budget in 1983.

A couple of areas I would like to touch on specifically where we think long-term research is needed and where there is a tremendous role, one, Mr. Lawrence already touched on it, and that is unconventional natural gas, where we are recommending $16 million. I think to put this in perspective in every day terms, if you consider that the DOE has reported, since NGPA was passed, there have been approximately 7,000 wells drilled in Devonian shale in the western tight sands and the average production of Devonian shale is only 55,000 cubic feet a day and in the western tight sands, it is 164,000 cubic feet a day.

The National Petroleum Council estimated that if you develop the technology, you could easily double the production, the average production per well. So you can see the tremendous potential in just continuing to fund this research in gas supply areas.

One other area I want to touch on is the technology development needed for the fuel cell. GRI is increasing its funding to pick up the entire cost of the field test for the onsite fuel cell program. It had previously been cofunded with DOE. That is increasing our budget from $11.3 million in 1982 to $19.6 million in 1983.

There is a continuing need for DOE to fund a long-term high-risk research in these areas as part of the original program plan.

In summary, it is especially important for the Government to maintain a strong long-term gas-related R&D program during the 1982–86 time period, while GRI and the gas industry and our member companies are taking the lead in near-term R&D. This requires a federally supported long-term gas research program of $104 million as has previously been discussed by Mr. Lawrence and Dr. Lee.

It should be noted that this recommendation, while totaling approximately $100 million, is less than the level of funds appropriated by Congress for gas-related research in fiscal year 1982 and it is only one-third of the fiscal year 1981 funding level. Therefore it is consistent with the Federal policy of reducing expenditures.

More importantly, the recommendation is also consistent with the projected funding for fossil energy research in the fiscal year 1983 contained in the Omnibus Reconciliation Act of 1981. In summary, it is the minimum level of Federal expenditures required to continue critical ongoing long-term gas-related research during this transition period, while the regulated gas industry picks up and continues the near-term research under its sponsorship.

Thank you very much, Mr. Chairman.

[The prepared statement of Mr. Webb follows:]

Statement of David O. Webb, Vice President
Policy and Regulatory Affairs
Gas Research Institute
Before the
Energy Research and Development Subcommittee of the
Committee on Energy and Natural Resources
United States Senate
April 26, 1982

Mr. Chairman and Members of the Committee:

I am David Webb, Vice President of Gas Research Institute (GRI), an independent, not-for-profit scientific research organization created by the gas industry in 1976 to plan, finance, and manage an expanded and fully coordinated gas-related research and development (R&D) program for the mutual benefit of the gas industry and its ratepayers. This program is annually reviewed and approved by the Federal Energy Regulatory Commission (FERC).

I am pleased to appear before you today to discuss my views on the Department of Energy's (DOE) FY 1983 Budget Request and to emphasize the continuing need for federal support of long-term, high-risk research on supplemental sources of gas and its more efficient use. Let me state right at the outset that the new emphasis on letting the market govern the development and introduction of new energy sources and technologies is basically sound. Having industry fund the near-term R&D and final technology demonstration prior to commercialization is also the correct approach since only industry can effectively introduce new products into the market. Thus while the shift in emphasis outlined in the National Energy Policy Plan (NEPP) is correct, it is such an abrupt change from past federal energy R&D policy that it will require an orderly transition with critical near-term R&D projects continued under industry sponsorship while long-term research is funded by DOE. Therefore, the proposed DOE budget which essentially eliminates all fossil energy and gas-related research in FY 1983 (even long-term, high-risk research) is a reversal of the government's stated policy of continuing to fund long-term research that industry will not fund due to market incentives. Implementation of this budget would be extremely shortsighted and not in the national interest.

The gas industry has responded well to the change in government R&D policy outlined in NEPP. GRI has promptly shifted its focus in line with the new federal budget realities, and its Board of Directors has authorized GRI to request from the FERC a 39 percent increase in its 1983 contract R&D budget to continue critical near-term projects previously cofunded with DOE. Specifically, in 1983 GRI will propose to increase its funding of near-term research by approximately $29 million out of a total increase of $33 million over its 1982 contract R&D budget ($84 million to $117 million). However, this proposed increase in GRI funding will be sufficient to fill only the most serious gaps in near-term gas-related research projects previously cofunded with DOE.

Importance of Gas in the National Energy Policy

To help determine the proper federal role and to assess the importance of continued federal sponsorship of long-term gas-related research, it is important to understand the fundamental linkage of the development of a strong gas technology base and a sound national energy policy. Today more than 85 percent of our energy is derived from fossil fuels with gas providing over 25 percent. DOE's NEPP projects that gas will continue to supply over 20 percent of the nation's energy in the year 2000. However, the key to achieving these projections is developing advanced technology so that gas will remain competitive in the industrial and power plant markets. Natural gas currently supplies more than one-third of the energy used by the industrial sector--the energy equivalent of over 4 million barrels of oil per day. In addition, gas provides 15 percent of the primary energy used for central power generation--equivalent to nearly 2 million barrels per day of oil. This market position is largely the result of price regulation which has made gas cheaper than less desirable fuel sources. Retention of this market has remained overly dependent on price, and the key factor to consider for future demand is the shrinking cost advantage of natural gas relative to competitive energy sources. The current deregulation path under the Natural Gas Policy Act (NGPA) or any other accelerated gas deregulation proposal assures that gas prices will increase at a faster rate than the prices of competing fuel sources. The best answer to rising gas prices is a strong technology response with industry assuming responsibility for the near-term R&D and DOE continuing the long-term, high-risk research. Without such a coordinated approach, the potential for major gas market losses due to fuel switching to oil is great. The impact of the United States' suddenly having to increase oil imports by up to 3 million barrels per day would severely disrupt the world oil market and reverse the present trend toward stable or slowly declining oil prices.

Capability to Develop an Adequate Technology Base in the Regulated Gas Industry

The gas technology base necessary to develop cost-competitive supplemental sources of gas and more energy-efficient processes and end-use equipment required to compete with alternative energy sources in the industrial and power plant markets is not established and in place. Although the gas industry is increasing its funding of near-term R&D to offset part of the DOE reductions, the gas industry has limited resources and capabilities to respond rapidly to this challenge compared to its major competition, the petroleum and electric industries. Essentially, the lack of a large and viable gas industry technology base primarily results from the following factors:

- Until the early 1970s, natural gas was in abundant supply and the required production research was conducted by the nonregulated petroleum industry. There was no emphasis on research for supplemental supplies.
- Regulation of gas prices at the wellhead resulted in gas being a cheap energy commodity; therefore, there was no emphasis on efficient utilization or end-use research.

- Since gas was cheaper than other competing energy sources, the emphasis for end-use appliances and processes was lowest cost, not efficiency or low life cycle costs. This greatly reduced the need for a strong technology base.
- There was a strong federal preference for and a long history of federal funding of a large R&D program for electric options (13:1 electric to gas based on the 1982 DOE budget). No similar programs existed for the gas option.
- The regulatory mechanism of controlling the total rate of return on invested capital that is used and useful in public service inhibited funding of a strong gas technology base.

As presented below, the net result is the current inadequate gas technology base and the limited capacity to rapidly expand funding of R&D.

TECHNOLOGY BASE DEVELOPMENT CAPABILITY

	Petroleum	Electrics	Natural Gas
Vertical Integration	Yes	Yes	No
Impact of Supply Deregulation	Very Positive	Possible Threat	Very Negative
Technical Capability	Very Strong	Strong	Limited
Internal R&D Funding Capability	Excellent- Large Corporate Units, High Returns, Large Tax Credits	Limited by Regulation	Limited by Multilayered Regulation
Manufacturer Support	Very Large- Transportation (with DOD), Chemicals, Most End Uses	Very Large- Most Supply & All End Uses (G.E., Westinghouse, etc.)	Limited
Federal RD&D Support	Very Little	Very Large- DOE, TVA	Very Little
Federal Commercialization Support	Limited - SFC	Very Large- Nuclear	Some - SFC DOE (Great Plains)

DOE's Energy Research Advisory Board (ERAB) put these factors in proper perspective in its report Federal Energy R&D Priorities dated November 1981.

> ERAB is concerned that some energy R&D of great potential significance for the achievement of the Nation's energy goals will fall between federal and industry responsibilities.
>
> The new policy recognizes that private industry cannot be expected to do basic energy research or projects of long-term, higher risk character. But there are other circumstances in which it would be unrealistic to expect timely and effective assumption by industry of R&D . . . .

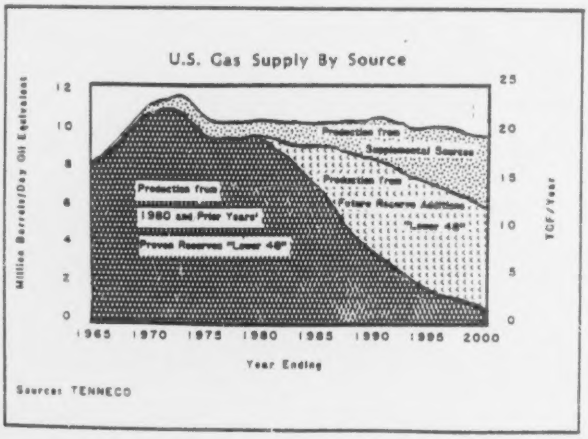
> Some of the markets in which energy is sold are not "free." Oil and coal are the exceptions. A little over half our primary energy finds its way to consumers through the electric and gas utilities, and the utilities are regulated, price-controlled industries, selling their products not at free market prices, but at controlled prices well below replacement cost.* The consequences are that consumers of gas and electricity have less of an incentive to conserve (and, therefore, to undertake research on conservation). . . .
>
> Both these regulated industries have weak incentives to spend on R&D. If successful, the benefits go to ratepayers; if unsuccessful, the expenditure may be disallowed as "imprudent."* In the case of electricity (but not gas), a substantial amount of R&D has been undertaken by large research-oriented equipment suppliers.... A strong R&D response to price signals requires both motivation and capability. In many cases the capability is simply lacking, and while it can be developed in given time, the time required to build a strong research organization is measured in years.
>
> *Emphasis added.

The ERAB report is a good statement of the differences between DOE's perception of regulated industry's ability to rapidly increase research funding due to market incentives and without government sponsorship, and the actual response of industry. One key problem is the difference in time frames used by DOE and industry to define near-term and long-term as applied to investment decisions. GRI's experience gained through cofunding many research projects with industry has been that industry will only contribute major resources to projects that have the potential to produce returns on investments in approximately five to six years. GRI has been very successful in obtaining significant increases in industrial cofunding; however, nearly all of the increases have occurred in near-term projects. Industrial partners have stressed that they must be able to identify a reasonable path to a marketable product within five to six years before committing themselves to large research investments. With gas prices increasing rapidly, the gas manufacturing and research industry must concentrate on the near-term research due to severe market pressures. If DOE does not continue to support and fund long-term gas-related research, then most of this research will be terminated since industry will not fund this research due to normal market incentives.

The National Interest in Assurance of Long-Range Supplies

Without adequate continued federal funding for the long-term R&D needed to establish this gas technology base, especially in the areas of least-cost options for supplemental supplies, the most probable result of rising gas prices is increased oil imports due to fuel switching in the industrial and power plant markets. Increasing quantities of gas production from supplemental sources will be needed by the nation over the next few decades to provide an assured supply to this critical market.

As illustrated in the following chart and based on DOE's recent projections, supplemental supplies of 4.6 Tcf plus nearly 3 Tcf of Alaskan gas and imports will be required in 2000 to meet demand. These supplemental sources will become available at competitive prices only through major improvements in technology. Therefore, establishing the technology base necessary to ensure the orderly development of these potentially abundant or renewable sources of gas is a national priority and requires a continuing federal role since it involves long-term, high-risk research.

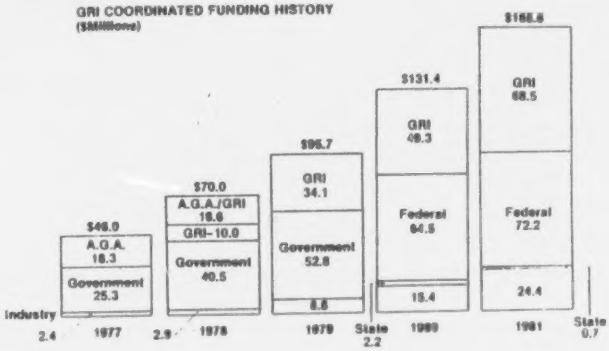

U.S. Gas Supply By Source

Source: TENNECO

Importance of GRI/DOE Cofunded Gas-Related R&D

Defining the proper role of industry and government in funding the required gas technology base can only be based on limited experience since it was only in the wake of the 1973/74 oil embargo that the government developed a truly comprehensive energy research plan which for the first time balanced nuclear, conservation, and fossil fuel R&D. In the early 1970s, the gas industry recognized the need for increased funding of its technology base and established the Gas Research Institute. The FERC approved the initial GRI R&D program and five-year plan in March 1978. With the federal emphasis primarily on long-term supply programs, the gas industry, through GRI, concentrated its funding increasingly on the nearer term options to offset as much as possible the impact of rapidly increasing gas prices. High priority was assigned to the residential and commercial markets to address urgent near-term problems such as the need for rapid introduction of high-efficiency gas space conditioning equipment. To cope with this immediate market problem and in response to the federal research policy as outlined in NEPP, GRI and the gas and manufacturing industries must now assume full responsibility for funding this research without waiting for possible resumption of federal R&D support.

The growth of the GRI contract R&D program has been impressive, rising from a level of $26.6 million in 1978 to $83.7 million in 1982. From its inception, in response to FERC guidance and encouragement by DOE, GRI has relied on extensive federal and industrial cofunding to carry out its research programs. GRI adopted a deliberate strategy to stretch the ratepayers' limited funds by cofunding or cooperatively funding projects of common interest with DOE and other government agencies. This highly successful effort resulted in a combined government and industry coordinated funding level of approximately $97 million in 1981. When combined with GRI funding for contract R&D, this funding amounted to a national institutional gas R&D program of $165.8 million in 1981 which was supplemented by approximately $40 million of research funded by individual gas companies to address issues unique to their service areas.



Revised Federal R&D Policy

Starting with the FY 1982 budget, the Administration has restructured the federal role in energy RD&D to conform to the following guidelines:

- The federal government will only fund long-term, high-risk R&D that will not be pursued by the private sector under normal incentives.
- The federal government will phase out of major energy demonstration programs.
- Industry should fund near-term R&D and commercialization.
- Industry should fund a greater share of R&D in response to market incentives.

As I mentioned earlier, the Administration's policy of increasing reliance on the private sector to fund near-term research in conjunction with continued federal funding of long-term, high-risk R&D is fundamentally sound. However, the severe and sudden impact on GRI and on gas-related institutional research in general is readily apparent in the change in the size and distribution of the DOE gas-related RD&D budget. The FY 1982 appropriation for gas-related RD&D was $180.8 million less than in FY 1981, and the total federal gas-related R&D budget is now slated to decline to only about $20 million in FY 1983 as shown in the following chart.

DOE GAS-RELATED BUDGET
($ Millions)

	FY 1981 Appropriation	FY 1982 Appropriation	FY 1983 Budget Request
Fossil Energy			
Advanced Research and Technology Development	$ 14.5	$ 12.5	$ 4.2
Enhanced Gas Recovery	30.6	8.7	0.0
On-Site Fuel Cells R&D	9.5	5.6	0.0
Surface Coal Gasification	164.9	53.1	10.5
Underground Coal Gasification	10.0	8.3	0.7
Geopressured Methane	35.8	17.3	2.4
Energy Conservation	22.0	10.5	0.0
Biomass	12.5	3.0	2.0
Total	$299.8	$119.0	$19.8

The sudden cutback of DOE gas-related R&D required a substantial change in the R&D strategy of GRI because the level of funding by DOE for gas-related research has a major impact on the scope and size of the GRI program. When the size or the trend of the DOE budgets in these areas suddenly makes a significant shift (either an increase or a decrease), it plays a major role in determining future GRI budget levels.

Gas Industry Response to Revised Federal R&D Policy

In response to the NEPP, GRI and the gas industry, with the active encouragement of DOE and the FERC, revised their funding priorities starting with the 1982 program to bring their projects in line with national policy. Through GRI, the gas industry significantly increased its 1982 funding for near-term R&D and will propose another major increase to the FERC for 1983. Out of a proposed GRI contract R&D budget increase of approximately $33 million ($84 million to $117 million), $29 million is for near-term projects in such areas as unconventional natural gas, regional and land-based biomass, on-site fuel cells, improved gas appliances, gas heat pumps and more efficient industrial utilization as defined in the following chart. These increases will partially offset the loss of DOE cofunding and coordinated funding for near-term research but will severely limit the ability of GRI to fund long-term gas research.

PROPOSED GRI NEAR-TERM R&D BUDGET INCREASES
($ Millions)

	Approved Budget 1982	Proposed Budget 1983
Unconventional Natural Gas	$10.61	$18.11
Regional and Land Based Biomass	2.90	5.30
On-Site Fuel Cells	11.35	19.55
Gas Appliances	3.98	6.65
Gas Heat Pumps	7.00	11.30
Industrial Utilization	7.95	11.75
	$43.79	$72.66

(Increase of $28.87)

Thus the recently submitted DOE FY 1983 Budget Request does not conform to the carefully delineated concept of the federal role contained in NEPP. The FY 1983 DOE budget also eliminates all gas-related commercialization and near-term R&D activities and, with the exception of a minor basic research program in coal gasification, also eliminates the federal role in strengthening the gas technology base through long-term, high-risk research that industry will not fund due to normal market incentives.

Options for Federal Support of Long-Term Gas Research

The proposed increase in GRI 1983 funding will only be sufficient to fill the gap in near-term gas-related research left due to the severe reductions in federal spending. Therefore, it is essential that the federal government maintain an adequate long-term research program to support the gas technology base. There are important high-risk, long-term, high-payoff areas of gas-related research that continue to require government sponsorship. This research is consistent with the Administration's policy guidelines and should be a national priority. Four specific examples follow.

Coal Gasification - $35 Million

One of the most promising long-term technologies meeting the Administration's guidelines for federal funding of energy R&D is coal gasification. While the technology base underlying surface coal gasification of western noncaking coals is relatively mature, additional research is needed in materials, catalysts, instrumentation, and downstream processing. A significant improvement in the economics of coal gasification could result from improvements in the downstream system since it comprises about one-third of the installed plant investment. New and promising approaches that have the potential to lower product costs by at least 20 percent compared to current technology must be developed through the "proof-of-concept" stage. Emphasis should be given to entrained and fluidized bed reactor systems.

Underground Coal Gasification - $10 Million

Underground coal gasification (UCG) offers the largest potential for major reductions in capital investment of the different processes and methods for producing a medium-Btu gas or synthesis gas from coal, but the high risks associated with the requisite oxygen-blown UCG technology currently preclude industry from developing the technology on its own. Before industry will be willing to make major investments, several basic technology issues must be resolved, such as the ability to successfully link modules. DOE should carry this program forward to the "proof-of-concept" point through multi-modules experiments. The benefits of a successful research program have national policy implications since the government owns or controls over four-fifths of the coal west of the Mississippi much of which is in beds that are too steeply dipping or deep or in seams that are too thin or of marginal quality to allow for economic surface or deep shaft mining. If successful, this technology could significantly increase the value of this coal and could greatly expand the use of the nation's vast coal resources.

Unconventional Natural Gas - $16 Million

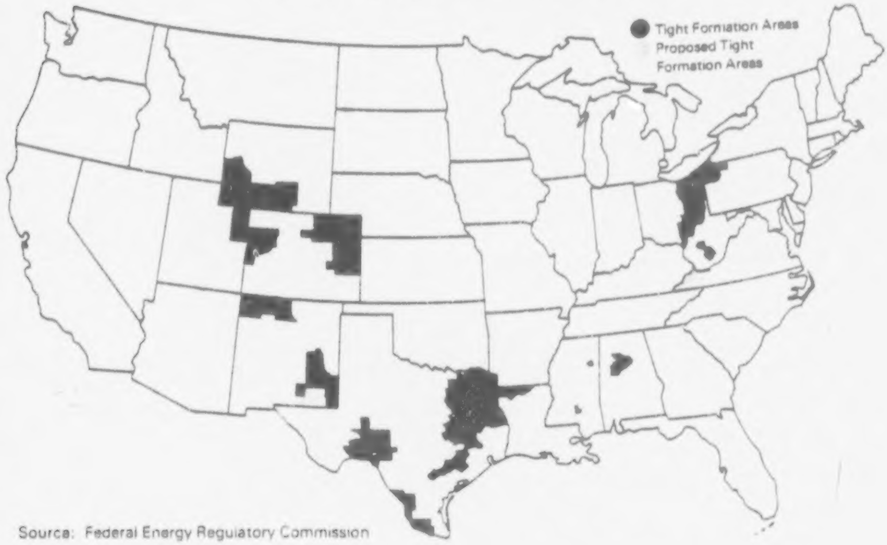
Another appropriate candidate for continued federal support is unconventional natural gas research in the tight lenticular formations in the West and in the Devonian shales in the East. The responsibility for production-oriented research and trial and error drilling should indeed be left with industry. GRI is increasing its research budget for this near-term work from $10.8 million in 1982 to $18.1 million in 1983. Federal funding should support experiments that are unlikely to be conducted by industry but that could greatly enhance our understanding of these formations. Two particularly good examples of novel experiments unlikely to be conducted by an individual firm, since the only product will be generic data on the formation stimulation technology, are the Eastern Mineback Program in the Devonian shales and the Multi-well Experiment in the West.

The Eastern Mineback Program is designed to substantiate the methodology and results of stimulation technology through a series of experiments. Unlike previous experiments, researchers will have the capability to make actual physical measurements and detailed observations of the shale in place to determine the effect of stimulation, the behavior and extent of fracture, and the accuracy of diagnostic tools, among other factors. Through this experiment to be conducted in eastern Kentucky, researchers will be able to assess the accuracy of present models and provide a realistic assessment of the in-situ reservoir.

The Multi-well Experiment in the tight sand formations located in the West is designed to obtain the maximum amount of technical understanding of lenticular formations. The normal economic constraints of a private firm would prohibit conducting an experiment of this type where wells are drilled far closer to each other than would ever be done commercially. This is necessary to allow flow and pressure testing between wells, well-to-well geophysical testing, and examination of geological continuity. The results are data and information that can be applied by a broad spectrum of industry and are, therefore, of national benefit.

When you consider the National Petroleum Council's (NPC) prediction that development of advanced technology could result in an increase of approximately 200 Tcf of recoverable gas from these tight formations, then you can understand the magnitude of the benefit to the nation of continuing this long-term research. To illustrate the potential of developing advanced technology, statistics from the most recent EIA Monthly Energy Review can be used. The EIA reported that wells currently qualifying under Section 107 of the NGPA as Devonian shale wells have an average production of about 20 MMcf per year or only 55,000 cf per day. At the same time, the EIA reported that Section 107 tight sand formation wells averaged gas production of 60 MMcf per year or 164,000 cf per day. Since Devonian shale formations underlie the Appalachian region and tight sand formations underlie Ohio, Texas, New Mexico, and the Rocky Mountain states (see map below), the successful development of fracturing and stimulation technology that would double the production per well as predicted by the NPC would have a tremendous national benefit. This requires a continued federal program in unconventional natural gas research.

Figure 10. Tight Gas Formation Well Areas



Source: Federal Energy Regulatory Commission

Advanced Fuel Cell Technology Development - $15 Million

The gas industry and GRI is proposing to make a major increase in near-term funding for on-site fuel cell systems in 1983 (from $11.3 million in 1982 to $19.6 million in 1983) to offset the loss of DOE funds. These funds will be used to continue the manufacturing and field testing of 45 units initiated under the joint program with DOE. This total assumption by the gas industry of funding for the field tests in 1983 and 1984 is consistent with national policy to have industry fund near-term demonstrations. However, the continued funding of the required long-term technology development program to increase the reliability of the units and lower the costs of these on-site systems is a federal role that cannot be simultaneously absorbed by industry. DOE has a long-term role to develop better materials, catalysts, and heat recovery systems needed to assure that these total energy systems realize their potential. A minimum DOE program of $5 million is required in FY 1983 for this long-term research on the on-site 40 kW fuel cell system.

Also, continued long-term research is needed on advanced fuel cell concepts such as molten carbonate and solid oxides. These systems have the potential to be more efficient and to lower overall costs of energy. It is important that the government continue this long-term fuel cell research while the gas industry assumes funding for the near-term research and field testing of prototype units.

Summary and Recommendations

It is especially important for the government to maintain a strong long-term gas-related R&D program during the 1982 to 1986 time period while GRI and the gas industry take the lead in near-term R&D. This requires a federally supported long-term gas research program of $104 million (as detailed in the following chart).

RECOMMENDED FY 1983 FEDERALLY-FUNDED
GAS RESEARCH PROGRAMS
($ Millions)

Tight Sands (Lenticular)	$ 6
Devonian Shale (Eastern Mineback)	6
Advanced Unconventional Natural Gas (Gas Hydrates, Abiogenic Methane)	4
Underground Coal Gasification	10
Geopressured Methane	16
Coal Gasification	35
Advanced Fuel Cell Technology Development	15
Biomass Conversion	3
Genetic Engineering and Biomass Growth	2
Advanced Gas Prime Mover	4
Hydrogen	3
TOTAL	$104

It should be noted that this recommendation, while totalling $104 million, is less than the level of funds appropriated by Congress for gas-related research in FY 1982 and is only one-third of the FY 1981 funding level. The recommendation is also consistent with the projected funding for Fossil Energy research in FY 1983 contained in the Omnibus Reconciliation Act of 1981. It is the minimum level of federal expenditures required to continue critical, ongoing, long-term gas R&D programs.

Senator **Ford**. Thank you.
Mr. Podolny.

STATEMENT OF WILLIAM H. PODOLNY, VICE PRESIDENT AND GENERAL MANAGER, FUEL CELL OPERATIONS, POWER SYSTEMS DIVISION, UNITED TECHNOLOGIES CORP.

Mr. **Podolny**. We appreciate the opportunity, sir, to make comments on this year's budget outlay for fossil energy R&D. In particular, I am vice president of power systems at United Technologies and responsible for fuel cell development.

This committee has been a strong supporter in the past and has recognized the potential benefits that this type of power equipment can provide to the Nation. As a result we have ongoing two great experiments, an experiment to demonstrate large-scale electric utility operation in New York and Mr. Webb described the joint operation with the gas utilities as demonstrated in the onsite use of fuel cells with its great contribution to conservation and cost of service.

Both of those activities are necessary and part of a basis of an ongoing concurrent, all private sector activity consistent with the administration policy to go forth in an attempt to commercialize the equipment with commercial prototypes for the electric utilities sometime in mid-1986 and to be shortly followed by a commercial prototype for the gas utilities in 1987 or 1988.

Those two joint ventures are all private sector. The electric utility venture is in the order of several hundred million dollars. The venture for the gas utilities will not be quite so large in magnitude and they are dependent upon the ongoing test that we referred to, plus the fact that they are high-risk and based on the technology that we can expect from today's basis.

The utilities and the industry are really looking forward to a requirement in the 1988 to 1990 period where the Nation will need increased capacity that will be consistent with the ability of the fuel cell powerplant for low-cost conservation, stability, reliability, durability, fuel flexibility. But the success of these ventures is really dependent upon the continuance of the support of base technology.

We find that the present policy in the administration and the support for fossil energy, in particular fuel cell activity, is inconsistent with the idea of the private sector taking on the responsibility of commercialization, but the public sector taking on the responsibility for long-range technology development that is critical to the ultimate success.

We would like to see as a minimum the support for fuel cell development to be consistent with the 1982 approved legislation. Thank you.

[The prepared statement of Mr. Podolny follows:]

Testimony of

William H. Podolny
Vice President and General Manager
Fuel Cell Operations, Power Systems Division
United Technologies Corporation

before the

Committee on Energy and Natural Resources
U. S. Senate

April 26, 1982

Mr. Chairman and members of the Committee, thank you for the opportunity to appear before this committee to address the adequacy of the Department of Energy's fuel cell budget. Let me begin by acknowledging the key role this committee has played in providing the funds required to execute the DoE fuel cell research and development program now in place. This includes significant cost-shared support of field testing of an experimental 4.8 MW electric utility system in New York, and similar support for the evolution and field testing of on-site fuel cell energy service in cooperation with the natural gas industry. The federal government, in recent years, has become a valued partner in continuing private sector efforts to develop fuel cell technology. Today, I would like to address the issue of the appropriate federal role in future fuel cell research and development from the perspective of a participant in the private sector effort that began at United Technologies in 1959.

United Technologies has accepted the challenge to bring fuel cell powerplants to the marketplace with the resources of the private sector. I will outline our plan to accomplish this task in the course of my testimony, but let me say at the outset that the success of this venture may very well hang on the willingness of the federal government to assume a necessary and constructive role in supporting high risk, long payout fuel cell technology base activities. This fundamental research and development buttresses the ability of the private sector to take these research results and apply them to new products and processes. Without this mutually beneficial division of responsibility, the private sector will be unable to perform its proper role in commercialization.

Let me briefly describe the fuel cell powerplant. In it a wide range of existing or planned fuels are converted to electricity and useful heat more efficiently and with less environmental impact than any other form of energy conversion. The powerplant chemically transforms the raw fuel to hydrogen; converts hydrogen and oxygen from the air to dc power; and, converts dc power to grid-quality ac power. Heat generated by the conversion process can be recovered for cogeneration applications. Suitable raw fuels include light petroleum distillates, natural gas, coal-derived gases and liquids and gases produced from biomass and some industrial by-product gases.

Because the fuel cell's electrochemical conversion is static and essentially independent of scale, the system is uniquely efficient over a wide range of power ratings and at part-power operation. Noise and emissions are dramatically lower than combustion-based generators and external water is not required for fuel processing or cooling. With these fuel, siting and operational features, fuel cells provide electric utilities with an important option for today's uncertain business environment.

The fuel cell powerplant can also address a critical economic problem if it is introduced into commercial service in a timely manner. The cost of energy service has been rising at a rate in excess of the general inflation rate in recent years. Because utilities do not have the same unregulated price and tax benefits provided to the rest of the private energy sector, they have little discretionary capital to invest in efficient equipment. As a result, the costs of all goods and services with an energy content are needlessly inflated. Incremental additions of fuel cell equipment in the 1980s and 1990s can begin to address that inefficiency.

I. Private Sector Commercialization

As this committee is aware, United Technologies has been involved in a number of private and government-funded experimental and developmental fuel cell powerplant programs during the past decade. I will limit my observations to our attempts to provide a commercially acceptable, phosphoric acid, electric utility generator because this program provides a clear illustration of the appropriate role of federal government in supporting energy research and development.

During the past eighteen months United Technologies has been developing an all-private-sector program to commercialize electric fuel cell generating equipment for electric utilities. Changes in federal policy, together with significant accomplishments in the technology and powerplant system design, have resulted in an explicit strategy to make commercial fuel cell powerplants available to the industry before the end of this decade. The critical elements include:

a. Essentially an all-private-sector endeavor.

b. A product development and verification program culminating in the delivery of early commercial units to at least 3 utilities in the 1986 period.

c. A concurrent commitment by utility companies for a minimum number (approximately 20) of prototype production units, with delivery starting in the 1988 period.

d. The participation of a major electric utility equipment designer and manufacturer as a venture partner to enhance the success of initial equipment deliveries and to provide long-term support and service for future commercial sales.

e. Continued strong technology research and development support by the U. S. Department of Energy and the Electric Power Research Institute at least through the point at which successful operation of the three early -delivery units is achieved to complement what would otherwise be a private sector activity.

Progress is being made toward identifying the initial utility applications for a nominal 10 MW powerplant and discussions are going on with several potential venture partners. Our goal is to have both of these relationships established by the end of this year.

There are three points of the plan that should be emphasized. First, it represents a strategic objective that will evolve over time in response to changing conditions. Second, the business and technical risks to be borne by the early-delivery utility customers and to the venture partner are extraordinary. Third, the technology base support of the federal government is an integral and essential part of the program.

Participating utilities will be asked to pay a premium for early delivery units under the program. They can justify this investment, in part, on the basis of the fuel cell powerplant's projected performance in the grid system. In addition to providing high-efficiency, fuel and siting flexibility, and low emissions, the fuel cell powerplant can reduce transmission and distribution costs, reduce reserve margin requirements, improve real power response, improve reactive power control, and provide one of the best options for industrial cogeneration. In addition to these operational benefits, the powerplant will be modular and factory-assembled, designed to minimize on-site construction costs and reduce lead times with attendant financial benefits to utilities. At present, raising new utility capital is difficult because of the large percentage of assets tied up in construction work in progress and the resultant large percentage of income derived from allowance for funds used during construction. Fuel cell powerplants permit incremental, short lead-time additions to capacity, thus easing the financial squeeze.

Despite this impressive list of potential benefits, the technical and business risk to the utility participants and venture partner remains substantial. These high-level business risks are appropriate for the private sector to assume, but they make sense for the participants only if the technology base for phosphoric acid fuel cells is assured of continuing federal support. While commercialization, with its attendant business risks, remains an exclusively private sector activity, technology research, with its focus on reducing technical uncertainty, is an appropriate function of the public sector.

II. Technology Base Support

The utility marketplace requires reliability, durability and competitive cost in new equipment. Although phosphoric acid fuel cell technology has seen substantial strides in recent years, a great deal of technology work remains to be done. The materials on which fuel cell technology is based are limiting factors on performance, durability and cost. Present configurations push existing materials to the limits of their capability. For example, the fuel reformer is constrained by the temperature limits of reformer tube materials; the cells are limited by the catalyst layer and catalyst structure; and the inverter and controls are limited by the applicability of new solid-state materials and devices.

The fundamental task of a base technology program is to increase the range of available options by testing new materials, adapting existing materials to new uses, and applying new and existing materials in new configurations. Each of these candidate materials must be exposed to the full range of experimental conditions, including different corrosive environments, widely varying pressures and temperatures, and normal cycling loads. In addition, materials must be shown to have the endurance and performance required for years of continuous utility service.

No private sector commercialization program can thoroughly address these basic research tasks. Nevertheless, they are essential in the evolution of fuel cell technology. The range of technical options is a direct function of federal generic research funding levels. The breadth of those technical options is the primary factor in establishing an acceptable technical risk for private sector participants in commericalization. The larger the federal investment, the higher the confidence of the private sector that the technology improvements will, in the future, become available for commercialization.

III. Private Sector Market Pull: The Window of Opportunity

The potential market for fuel cell powerplants in the late 1980s is indicated by the data of several recent utility market projections. Perhaps the most interesting recent study is a DoE examination of financial constraints on the electric utility industry. The study found that under a financially-constrained case in which utilities could finance only 50 percent of coal and 80 percent of nuclear plants planned or under construction, as much as 50 gigawatts of other generating capacity would be required by 1995 to meet peak demand. That demand could be met most efficiently, and ultimately at lower cost to the consumer, by fuel cell powerplants.

If the electric utility fuel cell powerplant were to achieve full commercial availability by the late 1980s, it would be in a position to compete for this market. Clearly, the time has come to position fuel cells for the market place. While the federal government has no formal role in responding to the market, an appropriate level of federal support for base technology activities might allow the fuel cell to be "pulled" by the market into commercial service.

IV. Conclusion

United Technologies is engaged in a good faith effort to bring a new technology to the market place. We have accepted the challenge to create an all-private-sector program toward that end. Our program calls on all parties in the venture to assume extraordinary financial and technical risks in bringing the fuel cell powerplant into commercial service. These parties cannot be expected to exceed the limits of prudent business practices. For potential customers to responsibly accept the risks involved in early delivery powerplants, it is crucial that federally-supported technology base activities continue on the underlying fuel cell technology

We are convinced that a fuel cell powerplant can be extremely attractive to utilities in the years to come. We believe the advantages of short lead time, cost, siting flexibility, energy efficiency, and other factors will prove to be extremely valuable to the utilities and their customers as they seek to meet projected load growth in a difficult financial environment. These advantages will not, however, be considered in a vacuum. Unless the utility has had experience with the technology or has access to other utilities that have used the system, it will lack the confidence to invest in a fuel cell powerplant.

We firmly support the Administration's general economic recovery program. Within that framework, the federal government can play a legitimate and valuable role in support of private sector technology development by sustaining fuel cell base research. White House budget documents argue that the "Government can perform an important role in support of private sector technology development by focussing federal funding on technology base research with widespread application (e.g., materials research or understanding the mechanisms of catalysis)..."* What we seek is implementation of this White House policy through adequate funding of fuel cell technology. Continued funding at the FY'82 level of $34.5 million for fuel cells, with $21 million for phosphoric acid technology base activities, may make the difference between success or failure of the private sector's program to bring fuel cells into commercial service.

Thank you for this opportunity to appear before your committee.

*Executive Office of the President, Major Themes and Additional Budget Details, Fiscal Year 1983, p.98.

Senator **Ford**. Mr. Brown.

STATEMENT OF DAVE BROWN, PRESIDENT, BOARD OF DIRECTORS, MHD INDUSTRIAL FORUM

Mr. **Brown**. Mr. Chairman, my name is Dave Brown. I am president of the board of directors of the MHD Industrial Forum with offices at 1725 DeSales Street NW., Washington, D.C. The forum was established in September 1981 to focus government and public attention on the tremendous energy and environmental benefits of the magnetohydrodynamic, MHD, technology.

The forum represents a broad spectrum of interests, industrial suppliers, research and development companies, individual scientists and scholars and utilities anxious to put the technology to practical use.

I would like to submit my full statement for the record, Mr. Chairman, and if I may I have statements from some of the member organizations, from Mr. John Kearney, senior vice president, Edison Electric Institute; Mr. Frank Fogarty, president and general manager, Mountain States Energy Co.; Joseph A. McElwain, chairman and chief executive officer, Montana Power Co.; Dr. John R. Sellars, vice president and general manager, TRW; and Dr. Robert Kessler, vice president of Avco Everett Laboratory.

Senator **Ford**. They will be included in the record following your statement.

Mr. **Brown**. I am here on behalf of my industry, utility and university membership to testify to the important role MHD power generation can play in the Nation's energy future. One of our gravest concerns is the lack of a consistent national energy policy and strategy.

Since the 1973 energy crisis, three administrations have failed to develop a comprehensive strategy for this Nation's energy future. Such a strategy must be a healthy component supporting the Nation's national security framework. Energy cannot, in my opinion, be divorced from our overall foreign and defense policies.

It is also clear that fossil fuels will supply a substantial part of the energy requirements for several decades to come. Almost 50 percent of the electricity generated in the United States is currently derived from burning coal. Projections show that by the year 2000, not only will coal account for 60 percent of the total electrical generation, but because of the normal increase in electrical demand, the total electrical generation from combustion of coal will have to double.

Doubling of the electrical generating capacity from coal will place a very serious burden on the electrical utility industry, the coal mining and coal handling industries and on the environment nationwide. In order to burn the large quantities of coal in an efficient and environmentally acceptable manner, utilities will need to turn to the newly developing advanced technologies.

The Federal Government does the Nation a disservice when it proposes to terminate or curtail research programs that enhance the use of coal at a time when the regulated electrical industry projects a struggle in meeting the projected demands on the next two decades.

The administration assumes that with the dissolution of DOE the development and demonstration of new technologies will be supported by private industry and done so almost overnight. With the current rate structures imposed by the Public Utility Commissions, the electric utility industry will find it impossible to absorb the added development cost and the cost of designing and constructing demonstration plants without the direct involvement of the Federal Government in any area.

Magnetohydrodynamics is a developing technology which is demonstrating a capability to provide the electric industry with an effective means of burning coal in the 1990's and beyond. MHD is the only new technology, which generates electricity directly from burning coal.

Numerous government and private industrial studies have shown that MHD offers the best combination of low cost of electricity, low pollution impact and high efficiency for baseload utility electric power applications. These studies have the credentials of the leading U.S. industrial companies and the results have not gone unnoticed by the electrical utilities.

Although in general very conservative, the electric utility industry is actively considering MHD as an alternative to offset increasing fuel costs, to facilitate the substitution of coal for oil, to repower existing plants and to provide new central station powerplants.

The Edison Electric Institute, EEI, has formed a task force on MHD composed of approximately 21 utilities and is presently formalizing the utility requirements for a commercial MHD plant. The Western Utilities Chief Executive Officers' Conference in January of this year adopted a resolution strongly endorsing continued Federal R&D support for MHD technology.

In addition, the Electric Power Research Institute has contributed several million dollars to MHD development. Most recently, it has invested $2.9 million in an MHD inverter to be used at the CDIF. The utility support for commercialization grows at an increasing pace.

Base load electric generating plants are large and costly. It is not reasonable to expect that private industry will be able to assume the full financial burden required to bring to commercialization a technology such as MHD.

The correct role of the Federal Government is to develop the technology base to a point where private industry will have the confidence to financially support a first commercial plant. Because of the critical role energy plays in our national economy and our national security, no reasooable technology should be terminated in its development cycle unless insurmountable problems are identified which would cast doubt on the technical merits or reliability of the technology.

MHD is a coal conversion technology which should be viewed as essential to provide a high electrical energy productivity with cleaner and lower cost power generating plants which will be required in the 1990's and beyond.

Although increased funding is a very sensitive matter at this time, the development of MHD should be continued and should receive a high national priority. The MHD Industrial Forum strongly supports to include in the $40 million for the MHD program in the DOE fossil fiscal year 1983 budget.

It is absolutely clear, Mr. Chairman, that priorities of the Department of Energy over the last 2 years have ignored the role that fossil energy will continue to play in the national energy picture and have ignored present or future prospects for technical progress of developing technologies.

It is an ill-conceived approach and does not represent the best interests of the Nation's future. The resolution of our energy problems should be one of our highest national priorities. If energy, particularly fossil energy, technology development programs are terminated or reduced to the point where substantial technical progress cannot be made, the critically needed energy options or alternatives again will not be available to this country at the time of the next crisis, and we may not be as fortunate in the future as we were after the 1973 OPEC oil embargo.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Brown, together with previously referred to statements, follows]

MHD INDUSTRIAL FORUM
Suite 805, 1725 DeSales Street, N.W. Washington, D.C. 20036 (202) 775-8609

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TESTIMONY OF

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COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

APRIL 26, 1982

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Mr. Chairman and Members of the Committee, my name is Dave Brown. I am President of the Board of Directors of the MHD Industrial Forum with offices at 1725 DeSales Street, N.W. - Suite 800, Washington, D.C. 20036. The Forum was established in September, 1981, to focus government and public attention on the tremendous energy and environmental benefits of the magnetohydrodynamic (MHD) technology. The Forum represents a broad spectrum of interests: industrial suppliers, research and development companies, individual scientists and scholars, and utilities anxious to put the technology to practical use.

I am here on behalf of my industry, utility and university membership to testify to the important role MHD power generation can play in the Nation's energy future. One of our gravest concerns is the lack of a consistant national energy policy and strategy. Since the 1973 energy crisis, three Administrations have failed to develop a comprehensive strategy for this Nation's energy future. Such a strategy must be a healthy component supporting the Nation's national security framework. Energy cannot in my opinion be divorced from our overall foreign and defense policies. It also is clear that fossil fuels will supply a substantial part of the energy requirements for several decades to come. Almost 50 percent of the electricity generated in the United States (25 quads) is currently derived from burning coal. Projections show that by the year 2000, not only will coal account for 60 percent of the total electrical generation, but because of the normal increase in electrical demand, the total electrical generation will have to be increased to about 42 quads. Thus by the year 2000, the total electrical energy generated from the combustion of coal will have to double (from 12.5 quads to 25.2 quads).

Doubling of the electrical generating capacity from coal will place a very serious burden on the electrical utility industry, the coal mining and coal handling industries and on the environment nationwide. In order to burn the large quantities of coal in an efficient and environmentally acceptable manner, utilities will need to turn to the newly developing advanced technologies. The Federal Government does the Nation a disservice when it proposes to terminate or curtail research programs that enhance the use of coal at a time when the regulated electrical industry projects a struggle in meeting the projected demands of the next two decades.

For example, the DOE Energy Research Advisory Board (ERAB) concluded that electrical supply related programs should receive a low priority with a substantial reduction or termination in funding. Essentially all coal related programs that are directed toward the production of electrical energy were recommended for curtailment. These conclusions are in error. If this policy is adopted, the electrical industry will receive a crippling blow that will stagnate the industry at a time when great progress is being made to improve the efficiency and enviromental control of coal burning systems.

The Administration assumes that with the dissolution of DOE the development and demonstration of new technologies will be supported by private industry

— and done so almost overnight. With the current rate structures imposed by the Public Utility Commissions, the electric utility industry will find it impossible to absorb the added development cost and the cost of designing and constructing demonstration plants without the direct involvement of the Federal government.

Magnetohydrodynamics (MHD) is a developing technology which has demonstrated a capability to provide the electric industry with an effective means of burning coal in the 1990s and into the next century. MHD is the only new technology which generates electricity directly from burning coal. Numerous government and private industrial studies have shown that MHD offers the best combination of low cost of electricity, low pollution impact, and high efficiency for baseload utility electric power applications. These studies have the credentials of the leading U.S. industrial companies and the results have not gone unnoticed by the electrical utilities. Although in general very conservative, the electric utility industry is actively considering MHD as an alternative to offset increasing fuel costs, to facilitate the substitution of coal for oil, to repower existing plants and to provide new central station power plants.

The efficiency of an MHD power plant can realistically be expected to be in the mid-40 to mid-50 percent range. Let me emphasize, this can be accomplished without any technological breakthroughs. This is in contrast to conventional coal burning power plants in operation today which have an efficiency in the low 30 percent range. This means an MHD plant would require approximately 33 percent less coal than a similarly sized conventional coal fired power plant. The benefits of requiring less coal in a power plant go far beyond the obvious advantages of conserving a natural resource and the reduction in fuel costs. A power plant requiring less coal will produce less pollutants (well below projected EPA performance standards) per kilowatt generated including less carbon dioxide and less acid rain, there will be less solid and liquid waste to dispose of and the plant will require less fresh water. The MHD technology promises improved environmental performance of coal plants, thereby facilitating licensing, increasing siting flexibility and expanding high sulfur coal utilization. These significant advantages of MHD and others are being considered by the electrical utility industry and by equipment manufacturers. Contrary to what you may have heard, there is strong utility support. The Edison Electric Institute (EEI) has formed a task force on MHD composed of approximately 21 utilities and is presently formalizing the utility requirements for a commercial MHD plant. The Western Utilities Chief Executive Officers Conference, in January of this year, adopted a resolution strongly endorsing continued Federal R&D support for MHD technology. In addition, the Electric Power Research Institute (EPRI) has contributed several million dollars to MHD development. Most recently, it has invested 2.9 million dollars in an MHD inverter to be used at the CDIF. Virtually every utility in the country is following the progress of MHD development because of its economic and environmental advantages. Their support for commercialization grows at an increasing pace.

The National MHD Program has been designed to establish the technology base from which commercialization of this process can eventually be performed by private industry. Two government funded test facilities (the Component Development and Integration Facility (CDIF) and the Coal Fired Flow Facility (CFFF)) have been constructed, and, with diagnostic instrumentation development support from Mississippi State University, have started to provide test results which confirm the theoretical analyses. Information from these facilities is vital to the decision by the electrical utilities to financially support the construction of commercial MHD plants. The reduction or curtailment of Federal funds supporting this technology at this crucial time in the development of MHD is not in the best interests of the country or the private sector. There have been no reports written by private industry which recommend the termination of this development program. Termination of Federal support now will shake industry investment in the technology.

Base load electric generating plants are large and costly. It is not reasonable to expect that private industry will be able to assume the full financial burden required to bring to commercialization a technology such as MHD. The correct role of the Federal Government is to develop the technology base to a point where private industry will have the confidence to financially support a first commercial plant. Because of the critical role energy plays in our national economy and our national security, no reasonable technology should be terminated in its development cycle unless insurmountable problems are identified which would cast doubt on the technical merits or reliability of the technology. To date there are no technology barriers that would prevent the development of MHD to commercialization. Nor has the engineering community had to revise its performance predictions. Ten years ago it was predicted that an MHD plant could achieve efficiencies approaching 50 percent. As development testing over the years provided improved engineering data, the predicated 50 percent efficiency has remained valid and even higher efficiencies appear possible.

During the past year, major milestones in technology development have been achieved. Coal combustor development work has demonstrated design feasibility with good performance of critical combustor parameters such as conductivity, slag rejection, heat loss, and high carbon conversion efficiencies. Tests have been conducted at the TRW facility utilizing a 20 megawatt combustor to verify performance and reliability over extended duration. Channel durability and electrode lifetime are critical issues in the development and commercial acceptance of MHD. The recently completed 1,000 hour duration test at Avco, which simulated coal-fired MHD channel operation by injecting fly ash and sulfur into an oil burner, extrapolated to a channel lifetime of 8,000 hours. Efficient superconducting magnets for use in the MHD process have been successfully demonstrated with the performance of a 40 ton, 5 Tesla superconducting magnet shipped to the USSR as part of the cooperative program and more recently by the completion and initial checkout of a 200 ton, 6 Tesla magnet built by the Argonne National Laboratory. Preliminary checkout of the 6 Tesla magnet showed the magnet exceeded design specification by producing a 6.2 Tesla field. In addition, major test facilities in the program have begun producing needed engineering data. These facilities and test data include heat and seed recovery and environmental performance data from the recently activated Coal Fired Flow Facility (CFFF) in Tullahoma, Tennessee, high energy extraction performance data from the High Performance Demonstration Facility at the Arnold Engineering Development Center, and 50 megawatt MHD power train performance data from the recently activated Component Development and Integration Facility (CDIF) in Butte, Montana.

In addition to the United States, several foreign countries have MHD development programs including Japan, Russia, China, Poland, India, and the Netherlands. By far the most ambitious programs are those in Japan and the USSR. The Japanese have a 15 megawatt oil-fired test facility at the Electro Technical Laboratory in Takasago. This facility includes both the MHD topping and steam bottoming cycles together in a single facility. The Soviets have a major test facility at the High Temperature Institute in Moscow. This is a 250 megawatt gas-fired plant with both topping and bottoming cycle components utilizing a low-field conventional magnet and has associated with it a smaller 25 megawatt thermal bypass loop which utilizes a U.S. supplied superconducting magnet. Furthermore, the USSR is designing a commercial scale, 500 megawatt gas-fired MHD power plant which should be completed by 1986 and is planning a commercial scale, coal-fired unit some time after 1990.

In a recent visit to the United States, a delegation of Japanese experts expressed interest in a cooperative program with the United States which could include an exchange of MHD test articles or direct financial participation of the Japanese in the MHD program in the U.S. Discussions of several hundred million dollars in Japanese participation did not deter their interest.

The development of any technology to the point of commercialization, is complicated by the number of steps required. This is particularly true for a technology being developed for the electric utility industry which requires a very reliable system, and therefore, it is essential that each new system be developed to a high degree of perfection before it is considered commercial. The existence of the MHD Industrial Forum, the EEI MHD Task Force, EPRI's private funding to date, the Western Utilities Chief Executive Officers resolution and others all attest to major industrial interest and participation.

The technology is just now entering a phase where major private or foreign investment will soon occur. But investments will not be made unless Federal support for MHD continues. To date the Federal Government's role has been the development of a technology data base and providing test facilities which have just begun operations for performance demonstration. Private industry has been involved in establishing design requirements and providing equipment and engineering services as contractors to the government. As demonstration testing proceeds, it is fully expectd that the role of private industry will shift from contractor to that of investor. The next step in the path to commercialization will probably be a small size commercial demonstration plant which will have a substantial financial commitment from the private and foreign sectors. The demonstration plant will then be followed by commercial power plants which will be funded completely by private industry. The commercialization of MHD will have very substantial financial participation by private industry, however, it is understandably premature at this juncture of the commercialization process. This applies to any advanced technology at this research and development stage.

Finally, the long term funding requirements of the MHD program must be addressed. DOE officials have correctly pointed out that funds required to bring the MHD program to the commercial market approximate $500 million. What they fail to point out is that only one half, or $250 million, of that amount over the next ten years will need to be Federal funds. If the U.S. program stabilizes in terms of Federal funding, substantial Japanese or other foreign funding in addition to industry, private and SFC funds are expected to produce the remaining $250 million dollars. With a Federal investment to date of $420 million (over $150 million in federal facilities and over $200 million in component development work), a cost benefit analysis of termination now would indicate the foolishness of not proceeding with development. I might also point out that while DOE management and other critics of MHD continually complain of the long term costs of the MHD technology, they rarely address similar complete cost of other new coal fired electric generating baseload plant technologies. When such cost comparisons are made, they usually involve comparing the cost of components of other new systems to the cost of a complete baseload MHD plant.

MHD is a coal conversion technology which should be viewed as essential to provide a high electrical energy productivity with cleaner and lower cost power generating plants which will be required in the 1990s and beyond.

Although increased funding is a very sensitive matter at this time, the development of MHD should be continued and should receive a high national priority. The MHD Industrial Forum strongly encourages the Committee's consideration of $40 million for the FY 1983 DOE/MHD Program.

It is absolutely clear that priorities of the Department of Energy over the last two years have ignored the role that fossil energy will continue to play in any National energy picture and have ignored present or future prospects for technical progress of developing technologies. It is an ill conceived approach and does not represent the best interests of the Nation's future. The resolution of our energy problems should be one of our highest National priorities. If energy (particularly fossil energy) technology development programs are terminated or reduced to the point where substantial technical progress cannot be made, the critically needed energy options or alternatives again will not be available to this country at the time of the next crisis -- and we may not be as fortunate in the future as we were after the 1973 OPEC oil embargo.

STATEMENT OF

THE EDISON ELECTRIC INSTITUTE

My name is John J. Kearney and I am a Senior Vice-President of the Edison Electric Institute. EEI is the association of investor-owned electric utilities in the United States and its members provide over 78% of the electric power used in this country.

I am appearing before you today on behalf of the investor-owned electric utilities in support of an increased Fossil Energy Research and Development Program for the Department of Energy, specifically in the area of Magnetohydrodynamics (MHD). Without continued support by DOE of research in coal-fired MHD, the potential use of this technology by electric utilities will be foreclosed for the foreseeable future.

During 1981, electric utilities burned over 590 million tons of coal, or approximately 78% of the coal consumed in this country. By the year 2000, it is estimated that electric utilities will be consuming almost 1.3 billion tons of coal annually. Coal-fired electric powerplants currently provide the majority of our electricity and will continue to do so into the next century.

The technology for using coal to produce electricity today is essentially the same as it was 60 years ago. That technology has reached the limits of its development, with maximum powerplant efficiencies of about 35%.

New technologies for the generation of electricity are needed to get the maximum amount of energy from coal with the least environmental disturbance. MHD is one important approach towards meeting these objectives.

Future combined cycle MHD plants are projected to have a coal pile to power grid efficiency of over 50%. Furthermore, these combined cycle plants have the potential for exceeding current EPA emission requirements without costly flue gas scrubbers.

Some of the areas of MHD technology which have seen recent major accomplishments include:

- generator durability and performance
- coal combustor
- superconducting magnets
- environmental performance
- seed recovery

These program achievements have led researchers to state that no technological breakthroughs are required in the MHD area. What is still needed, however, is further individual component testing leading to the design of an Engineering Test Facility (ETF). The ETF is the vehicle which will provide a demonstration of the commerical capability of MHD.

The utility industry supports MHD development. Several EEI companies have been pioneers in MHD over the past 15 years, most notably Montana Power Company, Southern California Edison Company, Pennsylvania Power and Light and Duke Power Company. In 1980, these utilities, together with six others, formed an MHD Utility Users Group to assist in furthering MHD research. Last year's progress in the MHD program, due in considerable part to the continued support of this Subcommittee, created additional interest in MHD within the utility industry. As a result, the Users Group has now been formally established as an EEI MHD Task Force with 21 members.

As part of their support for the MHD program, and to make certain that the information developed at the various test facilities reflects ultimate user requirements, the EEI Task Force has undertaken a cooperative project to define the minimum acceptable performance requirements for the advanced MHD test system. Under consideration is a second phase of the project, whereby the performance requirements will be expanded into functional and operational requirements for use in the development of a conceptual design for an MHD process demonstration unit.

The State of Montana has financed Phase I, in cooperation with the Montana Power Company. Montana Power and the other utility members of the MHD Task Force are providing substantial manpower to support this effort.

In summary, the utility industry believes that the MHD technology has the potential for greatly improved efficiency in the utilization of coal for the generation of electricity together with reduced environmental impact. As I have indicated, the utility industry is supporting the MHD program; however, without continued DOE participation in the funding of research, the development of coal-fired MHD technology will essentially cease. We believe it is premature to write off such a promising technology at this point.

Mountain States Energy Inc.
POST OFFICE BOX 3662
BUTTE, MONTANA 59702
(406) 723-8182

TESTIMONY OF

FRANK FOGARTY

PRESIDENT

MOUNTAIN STATES ENERGY, INC.

PRESENTED TO

THE HONORABLE PETE V. DOMENICI

CHAIRMAN

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

April 20, 1982

Mountain States Energy Inc.
POST OFFICE BOX 3662
BUTTE, MONTANA 59702
(406) 723-8182

Mr. Chairman and members of the Committee, my name is Frank Fogarty. I am President of Mountain States Energy, Inc. Mountain States Enrgy is the operating contractor for the Department of Energy's magnetohydrodynamic (MHD) Component Development and Integration Test Facility in Butte, Montana. I am deeply appreciative of the opportunity to submit this testimony in support of adequate funding for the Department of Energy's fossil R & D programs and specifically MHD.

There is a large inconsistency in the Government's approach to the Nation's energy future; energy plays a strategic role in the Nation's economy and defense. A large portion of this Nation's energy needs are being met through use of fossil fuels. In the electric utility industry over 75 percent of the energy used in 1980 was coal, oil or natural gas, with coal providing 49 percent of the total energy used by the electric power industry. Projections for the next 20 years show a growing dependence on coal increasing to 69 percent of all electric generation by the year 2000. Yet in 1982 the Administration sought and received over 50 percent reduction of the fossil energy R & D budget and in 1983 is seeking a further reduction of approximately 75 percent.

If this Nation is to maintain its future energy options and minimize its dependence on foreign supplies, we must have a balanced energy R & D program which includes funding for fossil energy research. The major and continuing impact of electric power generation on the economy and environment necessitates that our energy options for the future include advanced coal conversion processes which will be both more efficient and more environmentally acceptable than current coal-fired power plants. MHD is one of the options we believe must be kept open and which we believe fits the Administration's guidelines for Federal support of high-risk and long-term technologies with a high potential payback.

MHD, which when fully developed will offer conversion efficiencies over 50 percent greater than current coal-fired power plants while meeting existing and postulated EPA standards, has application in two major areas of electric power industry. The first is baseload power stations providing either additional new plant capacity or as a replacement for older plants being retired. The second is a retrofit option to existing coal-, oil-, and gas-fired boilers. This retrofit option to existing oil- and gas-fired boilers can both increase efficiency and power output while concurrently converting these power plants to clean-burning coal. In addition to baseload power stations and retrofit to existing boilers, MHD can be used in conjunction with other advanced power conversion technologies such as fusion or in a variety of industrial cogeneration applications. Because MHD is a high temperature fossil fuel technology, research on MHD has also contributed to a variety of developments in high-temperature material science and plasma diagnostics which have had important applications outside of MHD.

During the past decade MHD technology has successfully made the transition from laboratory research to engineering-scale testing. Major advances have been made in virtually all areas of the technology. The problems that must be solved before coal-fired MHD power plants are commercially ready are engineering development problems that can only be addressed through larger-scale testing. Although no major technical breakthroughs are foreseen, demonstration of commercial readiness still requires considerable engineering-scale testing and involves substantial risk.

During the past year, major milestones in technology development have been achieved. Coal comnbustor development work has demonstrated design feasibility with good performance of critical combustor parameters such as plasma conductivity, slag rejection, heat loss, and high carbon conversion efficiencies. Tests have been conducted at the TRW facility utilizing a 20-megawatt combustor verifying performance and reliability over extended duration. Channel durability and electrode lifetime are critical issues in the development and commercial acceptance of MHD. The recently completed 1,000-hour duration test at Avco which simulated coal-fired MHD channel operations by injecting fly ash and sulfur into an oil burner extrapolated to a channel lifetime of several thousand hours. Avco is presently gathering data on a second 1,000-hour duration test on the same hardware to further verify the extrapolation. Efficient superconducting magnets for use in the MHD process have been successfully demonstrated with the performance of a 40-ton, 5-tesla superconducting magnet shipped to the USSR as part of the cooperative program and more recently by the completion of initial checkout of a 200-ton, 6-tesla magnet built by the Argonne National Laboratory. Preliminary checkout of the 6-tesla magnet showed the magnet exceeded design specification by producing a 6.2 tesla field. In addition, major test facilities in the program have begun producing needed engineering data. These facilities and test data include heat and seed recovery and environmental performance data from the Coal Fired Flow Facility (CFFF) in Tullahoma, Tennessee; high energy extraction performance data from the High Performance Demonstration Facility at the Arnold Engineering Development Center; and 50-megawatt MHD power train performance data from the Component Development and Integration Facility (CDIF) in Butte.

During the past year the CDIF has made the transition from facility activation to an operational test facility. In May 1981 the facility produced its first electrical power. Tests studying combustor and channel performance have been continuing since that time. Recent tests in February of this year signified the establishment of CDIF as a DOE operating facility. Subsequent tests resulted in the production of electrical power output at a level of 2.27 megawatts, the highest achieved to date. The installation of an EPRI supplied inverter which will allow the MHD produced power to be put onto the commercial power grid has been completed and initial demonstration tests are scheduled during the next month. Other major activities in this facility have been concentrating on activation of the coal system in preparation for coal-fired testing next fiscal year. The technology is rapidly advancing on all fronts and is now producing much needed engineering data. Remaining though is substantial effort. At CDIF, testing to date has utilized fuel oil and coal ash, rather than coal. The first coal combustor to be tested at this power level has been delayed by this year's FY 1982 funding level. The superconducting magnet mentioned earlier is setting idle with no funds to ship or install.

The MHD program in the past has been accused of being too costly. I believe this is in part based upon the original cost estimates for a three-phase program which included a commercial demonstration unit with a total program cost of over $2 billion. In 1981 the Department of Energy revamped this program to a two-phase program, eliminating the costly commercial demonstration unit. Total cost of the program to date has been less than $450 million. It should be noted that this cost includes the total technology development program, not just the component development or partial program development which is typical in other programs and probably represents over half of the total cost of developing the technology to the point where industry can assume the responsibility for commercialization. With the major investment made and the respective test facilities producing needed engineering data, closure of these facilities at this time would not be a cost-effective decision. Within the next few years the viability of this option could be determined. If funding is terminated now it would result in loss of expertise and possible costly restart of the program later. The MHD program needs funding at the $40 million level in FY 1983 if continued advancement is to be possible.

The technology has recently gained considerable support from the utility industry. A number of individual utilities and utility organizations are becoming actively involved in the technology and have submitted testimony to your committee. The Edison Electric Institute recently established a task force on MHD comprised of twenty-two separate utilities and the Electric Power Research Institute has been participating in the work at the CDIF with the investment of $2.7 million in the CDIF inverter system with follow-on support being considered. In addition, a number of individual utilities are becoming involved in the technology through a project funded through the State of Montana Department of Natural Resources and Conservation (DNRC). The state appropriated $500,000 for development of MHD in the State of Montana. Through this support, the Montana Power Company, using a broad-base of utility participation, is defining the performance requirements for commercializing MHD. Other utility companies are actively studying the feasibility of retrofitting MHD topping cycles to older oil- and gas-fired power plants to increase the plant capacity and efficiency while concurrently converting these power plants to clean-burning coal.

In addition to the United States, several foreign countries have MHD development programs including Japan, Russia, China, Poland, India, and the Netherlands. By far the most ambitious of these are the programs in Japan and the USSR. The Japanese have a 15-megawatt oil-fired test facility at the Electro-Technical Laboratory in Takasago. This facility includes both the MHD topping and steam bottoming cycles together in a single facility. The Soviets have a major test facility at the High Temperature Institute in Moscow. This is a 250-megawatt gas-fired plant with both topping and bottoming cycle components utilizing a low-field conventional magnet and has associated with it a smaller 25-megawatt thermal bypass loop utilizing the U.S. supplied superconducting magnet. Furthermore, the USSR is designing a commercial-scale, 500-megawatt electric gas-fired MHD power plant which should be completed by 1986 and is planning a commercial-scale coal-fired unit sometime after 1990.

In a recent visit to the United States, a delegation of Japanese experts expressed interest in a cooperative program with the United States which could include an exchange of MHD test articles or direct financial participation of the Japanese in the MHD program in the U.S.

In summary, this country's economic and energy future for the next 30 to 40 years is more dependent on coal as an energy source than any other substance. We have learned through experience in other areas that beside the major loss in the benefits of the R & D, complacency with our R & D efforts results in noncompetitive situations with foreign governments, costly shuffling of money and resources in time of crisis, and a loss in possible spinoffs and technology expansion. For the economic and defense benefits in the country, fossil energy research, specifically coal use research and development, must be increased, not decreased. The positive accomplishments and promise shown by MHD make it a forerunner in this effort.

Statement of Joseph A. McElwain
Chairman, The Montana Power Company

Subcommittee on Energy Research and Development
United States Senate
April 26, 1982

My statement to this subcommittee is in support of federal funding at a level of $40 million dollars for the Department of Energy, Fossil Fuels Research and Development, particularly Magnetohydrodynamics research.

The Montana Power Company is an electric and natural gas utility serving the western two-thirds of Montana and has subsidiaries which mine coal, in extensive coal holdings in Montana, Wyoming and Texas.

I will direct my comments to needs of the utility industry, the use of coal as a growing energy source, and the potential of the magnetohydrodynamics technology, or MHD, to meet the baseload plant requirements of electric utilities.

It is clear that coal must assume an increasing part of national fuel mix. It is also clear that advanced, efficient, clean burning technologies are needed if coal's proper contribution is to be achieved. This perspective is shared with an ever increasing number of utilities. The Western Utilities Chief Executive Officers unanimously adopted at their January 13, 1982 meeting a resolution and submitted it to the Energy Research Advisory Board of the U.S. Department of Energy. (See Appendix A for the full text and a list of the utility companies involved). This resolution summarizes The Montana Power Company's position.

The United States has not been moving with dispatch in this critical area of coal utilization. In 1974, coal accounted for about 44% of the energy utilities employed to produce electricity. In 1980, that figure had grown by only five percentage points --- to only 49% --- while the consumption of electricity had leaped 19%.

Looking just a few years into the future, the best forecasts indicate the demand for electricity will escalate 114% by the turn of the century, because electricity is that blessedly versatile form of energy that can serve many needs. Coal should and could be used to generate more than two-thirds of the electricity in this country, assuming attractive economics and superior technology. However, the proposed budget shows a substantial reduction in funding of fossil fuels research. Research funding that the utility industry cannot pick up. The utility companies are state regulated entities and there is not the flexibility in the rate structure to support the levels of research required.

Several advanced coal technologies will be needed for the utility industry of the future because of scale, type of load, availability of fuel, and location of plant. Among these advanced technologies are:

1. MHD

2. Fuel cells

3. Hot gas turbines, and
4. Pressurized fluid bed boilers.

All of these are important. However, for baseload, clean-burning coal-fired plants, MHD has the highest potential. Furthermore, MHD due to its cleanness, could be used as a retrofit to present oil fired plants.

Utility interest in MHD is based on two factors: the significant strides which have been made in research, and the imminence with which MHD promises to help meet a four-fold goal the utilities perceive as necessary for their customers. The goal is the evolution of a technology --- or combination of technologies --- which accomplishes these objectives:

- First, to burn coal with high efficiency, but without extensive advanced coal treatment and without gasification.
- Second, to operate with minimal environmental effects and with a reduction in scrubbing and exhaust gas treatment.
- Third, to produce lower-cost electricity - something to ease the pressure of inflation and cost pressures related to increased regulation.
- Finally, to prolong the life of our fossil fuels by materially increasing the efficiency with which we use those fuels.

MHD is the only technology of which I am aware that promises to increase coal combustion efficiency by as much as 50%. To suggest that kind of gain to the utility industry is akin to offering motorists a way to increase gas mileage from 30 miles per gallon to 45 miles per gallon. It is that spectacular...50% increased efficiency.

The fact is that the potential of MHD is being recognized within our country, and elsewhere in the world. In the United States, we have witnessed the formation of the Industrial MHD Forum and the utilities National MHD Users' Group. The Edison Electric Institute (EEI) in recognizing the need for coal options and the potential of MHD has recently incorporated the National MHD Users' Group into its new EEI MHD Task Force. Outside our country, there are active research and development programs for MHD in the Soviet Union, Poland, Yugoslavia, India, China, Netherlands, Sweden and Japan. The Japanese, in addition to their own program, have expressed an active interest in possible participation with the United States in development of MHD. Can all of these nations, as well as many of our own scientists, be wrong about the potential of MHD? I postulate that if we do not pursue MHD research, we may one day be buying this technology from other nations. However, today we are the world leaders in coal burning-MHD technology and in just a few years its viability can be proven.

The raw gain in efficiency is complimented by the ability to meet the second objective of utilities: to operate with minimal environmental effects while reducing the need for treatment of power plant emissions. The MHD process of generating more electricity from each ton of coal will produce a side benefit by removing sulfur from the emissions. Thus, MHD is expected to achieve the twin benefits of reducing pollution and reducing the cost of preserving air quality.

The cost of producing electricity through the MHD process also offers hope for the third objective --- that the beleaguered utility customers may look forward to mitigation of their monthly energy bills. The gain in efficiency will reduce fuel costs and capital investment. The result is that the customer may hope that electricity prices will be held down despite inflation and burgeoning regulatory costs.

The fourth benefit in prospect with commercial operation of MHD is the opportunity to better husband our single abundant non-renewable fuel resource. Coal constitutes roughly 77% of our domestic energy reserves, yet has been furnishing less than 20% of our energy needs.

Yet without MHD efficiency or some unforeseen exotic technology, coal cannot be expected to assume its destiny in our energy mix, nor can we hope to prolong the life of our coal supply.

Whether the promise will be realized in a timely manner is dependent on the National Energy Program and a congressional decision to fund or to abandon funding of the Fossil Fuel and MHD Programs.

Research to date has resolved the major questions about MHD. Nevertheless, the technology still is in the developmental stage. The scale is still too small to show conclusively its full potential to contribute significantly to the nation's energy needs. The risk inherent in moving forward to the point where MHD meets commercial conditions still is too great for the private sector to assume the largest share of the burden.

The MHD program qualifies in all regards for federal funding under the approaches stated in The National Energy Policy Plan, "Securing America's Energy Future," U.S. Department of Energy, July 1981. These criteria are:

-Public spending for long-term, high risk, high payoff technologies.

-Private investment capital unavailable.

-A less expensive alternative to imported oil.

-Generic research which benefits many companies.

Another criterion listed under The National Energy Policy III was that "The governments role is not to select and promote favored sources of energy. Doing so risks wasting the nations' resources." This correlation is even more fitting: The government's role should not eliminate critical sources of energy.

My company has proposed formally to the Department of Energy that the MHD Engineering Test Facility/Commercial Demonstration plant phase of the national program be integrated with a 350 megawatt coal-fired conventional plant scheduled for construction this decade near the City of Great Falls, Montana.

We would provide site development, support facilities, and operate the MHD plant. MPC would contract to buy electricity and steam produced by the federally-owned portion of the plant. Our support, of course, is contingent on the successful resolution of technical problems which will be solved only if the federal government affords the research effort sufficient support. The State of Montana also recognizes the potential of coal fired MHD and has funded The Montana Power Company (through the EEI-MHD Task Force) to define, from the utility industry point of view, the minimum performance requirements for a process demonstration unit. Twenty-one utilities are contributing their time and effort, worth over $100,000 to this project. This effort demonstrates the burgeoning utility interest in MHD and shows a strong desire that the DOE developmental program meet the needs of this vital industry.

I would like to add that as a non-technical person, I have listened to arguments of the proponents and opponents for more than twelve years. It is my observation that the proponents have been much more successful in realizing their claims than the opponents in having their assertions verified.

In summary, I urge adequate federal funding of the Fossil Fuels and MHD Research and Development Programs as a technology which has long-term promise and which transcends both parochial interests and the immediate federal commitment to a broad range of budgetary stringencies. MHD offers our nation, the consumer and the utilities serving them, exceptional opportunities to replace dwindling oil reserves with coal in our total energy mix. We can conserve and enhance our lone abundant energy resource by making the most efficient possible use of coal. We can burn coal in the most environmentally acceptable, efficient manner. We can facilitate the ability of utilities to meet national energy goals, and we can offer the user of electricity hope of genuine progress being made in combating the escalation of the price of that energy form. I believe continued support for MHD is imperative in the context of the national interest.

Thank you for your attention and consideration.

APPENDIX A

MONTANA POWER COMPANY MPC GENERAL OFFICES 40 EAST BROADWAY BUTTE MONTANA 59701 • TELEPHONE 406/723 5421

JOSEPH A. McELWAIN
CHAIRMAN OF THE BOARD
AND
CHIEF EXECUTIVE OFFICER

January 22, 1982

Mr. Louis H. Roddis, Chairman
Energy Research Advisory Board
Forrestal Building ER-6
Washington, D. C. 20585

To: ERAB

As Chairman of the Western Utilities CEO Conference, I am transmitting, herewith, a resolution adopted at our meeting January 13, urging continued federal support for the research and development program on magnetohydrodynamics. The member companies of our Conference are listed below. Your consideration will be appreciated.

Sincerely,

Joseph A. McElwain

Joseph A. McElwain

Western CEO Utilities Conference

Arizona Public Service Co.

Idaho Power Company

Montana-Dakota Utilities Co.

Nevada Power Company

Pacific Gas & Electric Co.

Pacific Power & Light Co.

Portland General Electric Co.

Public Service of New Mexico

Public Service of Colorado

Puget Sound Power & Light Co.

San Diego Gas & Electric Co.

Sierra Pacific Power Co.

Southern California Edison Co.

Tucson Electric Power Co.

Utah Power & Light Co.

Washington Water Power Co.

JAM:lw
Enclosure

RESOLUTION

The Western Utilities CEO Conference

The Western Utilities CEO Conference, meeting in regular Session on January 13, 1982; unanimously adopt the following resolution, and instruct the organization's Chairman to promptly convey this resolution to the attention of the members of the Energy Research Advisory Board of the U. S. Department of Energy in the most prominent and urgent manner available:

> "WHEREAS, the Western Utilities CEO Conference is composed of Chief Executive Officers of all the electric utility companies serving the 13 western states, joined together to foster the mutual interests of America's electric power consumers and the electric utility industry, particularly in the western part of the U.S. and,
>
> "WHEREAS, the efficient, flexible and cost effective generation and distribution of electric power is a vital component in the industrial and defense economy and capability of the U. S., and,
>
> "WHEREAS, the generation of electric power in the U. S. is seriously impacted by inflation, environmental restrictions, government regulation, high interest rates, high equipment costs, and a dearth of technology options, and,
>
> "WHEREAS, the use of this nation's immense coal resources for electric power generation -- given appropriate technology for coal's clean and efficient use -- represents the most feasible, long term energy option, and,
>
> "WHEREAS, the Energy Research Advisory Board (ERAB) of the U.S. Department of Energy has recommended the virtual elimination of federal support for Research and Development of coal-using energy conversion technology; therefore,

"BE IT RESOLVED -- that the Western Utilities CEO Conference strongly supports a national commitment to the use of coal for electric power generation in the U. S., as being in the best interests of the nation, electric power consumers, and the electric utility industry. The Western Utilities CEO Conference believes that magnetohydrodynamics represents one of the most efficient methods of utilizing our vast resources of coal for the generation of electric power, with greatly reduced environmental problems. We, therefore, urge ERAB to reconsider its no-funding recommendation on coal energy conversion research, and we recommend in particular that the MHD program receives continued support.

STATEMENT OF
JOHN R. SELLARS
APRIL, 1982

TRW has long been committed to enhancing existing energy resources and to developing new ones. In the Fossil Energy area we are developing advanced utility and industrial coal combustors and gasifiers. Our Gravimelt process is removing 90% of the sulfur and ash from eastern and mid-western coals. Our BEACON venture with SOHIO promises to convert low-BTU gases to hydrogen or cogenerate methane and electric power. We are conducting magnetohydrodynamic combustor R&D and are progressing toward operation of an advanced MHD power train. We are also active in oil shale development, coal-bed methane recovery and _in-situ_ coal gasification, all in support of this nations effort to better use our domestic resources. To this end, we have invested more than 15 million dollars in Fossil Energy technologies over the last six years, including the construction and operation of our own Fossil Energy Test Site near San Juan Capistrano, California.

I would now like to make a few remarks on the subject of our Nation's fossil energy research and development program. The budget I have seen for FY 1983 is nearly a factor of ten lower than the budget of only a year ago, FY 1981. While some tightening up may have been in order, in my opinion, such a reduction is too severe for the national good.

Let me review a few reasons why I believe in a strong national Fossil Energy R&D program: First, there is the incalculable worth of our resources (oil, tar sands, shale, and particularly coal). Their value can be realized only if we convert these resources to useful forms in an environmentally acceptable way. Clearly we have the energy in the ground for complete independence from foreign sources; indeed, we can become major energy exporters to the rest of the world. If our environment is destroyed or our national treasure of energy is wasted by inefficient recovery or usage, we will leave a poor legacy to our children.

Environmentally, cleaning up coal or converting it to other forms will surely be cheaper, for the economy, than stack gas scrubbers or acid rain on our land.

Second, the national security has a economic as well as a military side, as the events of the last decade have shown. At this moment, there seems to be a perception that the energy crisis is over and that the free market will take care of any future problems. Yet, we hear that future plans for synfuels and shale oil are being abandoned or delayed by private companies because of the present uncertainty in the price of crude oil. But with all of the drilling last year and the year before, no reports of "super-large" new oil fields have been made. In fact, U.S. new oil discoveries have leveled out. Corporations give very heavy weight to the short term effect on their profits and must do so almost by their nature; the federal government must therefore supply the necessary bridging continuity.

Third, the FY 1983 budget that I have seen states that the government is no longer going to assist in merely bringing energy technology to the market "earlier". If one feels that there is still an energy crisis, then bringing energy technology to the market "earlier" is precisely the point. In many cases some of the technology abandoned under such a policy will never reach the market in the forseeable future. Before it will pursue a new technology, industry must see a convincing demonstration of that technology and thus be assured of a reasonably return on investment. This is economics as it is practiced in the market place and it is certainly consistent with the free market philosophy. The U.S. government's role is to expedite the improved use of coal, making it a more valuable resource for U.S. industrial investment.

Finally, there is the crucial point of maintaining a consistent effort. A case in point is one of the most startling transformations of modern American society which resulted from a long-term, wide-spread research program sponsored by both our State and Federal governments. I refer to the change which took place in American agriculture in developing new strains of plants and animals, and in the technique of farming in general. This research program was carried out in colleges, universities, industry and government laboratories all over the country for many decades, and this research made the American farmer the most productive in the world. This could have not been done by on-again, off-again,start-stop programs. Nor can energy research and development be carried out without continuity and consistency. Many producers, distributors and users of energy are too small to carry out the needed development, just as individual farmers were. Even some of the larger entities, such as utilities, do not have the necessary technical staff to carry on these developments; even if they did, they are too strapped financially to respond alone.

In conclusion, I would like to point out that even during a global recession, Japan, the People's Republic of China, the USSR, Poland, Italy and Germany are continuing with government-funded fossil energy R&D. They will therefore reap the economic benefits of the technology and enhance their worldwide technical prestige. Without a strong, adequately funded, U.S. Fossil Energy Program, foreign nations will continue to usurp our technological world leadership, and as with the automobile, will surely in time erode the American Fossil Energy Equipment market, both at home and abroad.

I thank you, Mr. Chairman, and the committee for your consideration.

Summary of Statement
Submitted by

Dr. Robert Kessler
Vice President
Energy Technology Office

Avco Everett Research Laboratory, Inc.
2385 Revere Beach Parkway
Everett, Massachusetts 02149

for

Subcommittee on Energy Research and Development
of the
Committee on Energy and Natural Resources
United States Senate

26 April 1982

Very significant progress was made during the past year in the development of MHD power trains (combustor and channel or generator). A 1000-hour channel test was conducted at Avco Everett Research Laboratory, Inc. (AERL) under coal fired commercial power plant conditions. The test demonstrated that electrode lifetimes of up to 8000 hours are possible. (Electrodes are the most critical part of an MHD generator). This test result meets a utility industry requirement for early commercial power plants.

Experiments conducted at the Arnold Engineering Development Center achieved performance levels of 10.5% enthalpy (electric energy) extraction which confirmed the theoretical predictions which are the basis for projections of commercial MHD power plant performance. The test, conducted on a generator about half the size needed for an early commercial MHD plant, provided good confirmation that MHD components can be scaled to commercial size.

An MHD coal combustor developed at TRW will begin actual coal fired operations with an MHD generator at 20 MW levels at AERL later this spring. These tests will provide engineering and performance data for the operational demonstration of a 50 MW power train scheduled for integrated tests at the Component Development Integration Facility (CDIF) in 1983.

The University of Tennessee operated a 28 MW MHD generator, resulting in NO_x and SO_x levels well below EPA's new source performance standards. Argonne National Laboratory built and successfully tested a 200 ton, 6.2 Tesla superconducting magnet.

It can therefore be concluded that if properly funded, the technology development program now being conducted by DOE's MHD office will make it possible to begin the commercialization phase of MHD development within the next four to five years.

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MHD is a direct energy conversion process which offers distinct and important advantages for the production of electricity from coal. In the MHD system, coal is burned to produce combustion products at about 4500°F, which are seeded with a potassium salt. Under these conditions, it is a good conductor of electricity and in accordance with Faraday's principle, generates electricity as it passes at high speed through a magnetic field. The principal components of an MHD flow train are a combustor, an MHD channel, or generator, and a magnet. While not directly involved in the electric generating process, environmental control of an MHD power plant is also important.

The inherent mechanical simplicity of the MHD generator, with no moving parts, makes it possible to burn coal directly and to handle very high temperature combustion gases containing ash impurities which would quickly destroy a turbine. Because of its high temperature capability, a much more efficient use of the fuel is possible. Also, since the coal is burned directly, there is no loss associated with prior coal gasification or liquefaction. Numerous studies show that mature MHD power plants will produce 50% more electricity from the same amount of fuel as compared to the most efficient conventional steam power plants in use today. It is important to note that the more efficient use of the fuel in MHD power plants will be coupled with significant reductions in environmental intrusion. Experimental and analytical work has verified that MHD power plants can be designed with pollutant emission levels far below existing and future environmental standards and regulations.

I would like to stress that there are no fundamental scientific obstacles to the development and commercialization of MHD power generation. MHD requires an aggressive engineering program leading to a demonstration of commercial power plant operation.

In the following sections, I will discuss the status of each of the principal components of MHD power generation and more briefly the economic and environmental advantages.

Channel

The MHD channel is the heart of the MHD power generation system, since it is the component which produces the electric power and its requirements determine the specifications for other components and subsystems of the MHD power plant.

The major issues in channel development are whether adequate efficiency and enthalpy (energy) extraction can be achieved simultaneously and for sufficient duration to satisfy requirements for commercial operation. In 1981, significant steps were taken toward addressing these technical issues.

With respect to long duration channel operation, the most significant event in 1981 was the successful completion at Avco Everett Research Laboratory of a 1000-hour generator test (Figure 1), conducted under the same chemical, electrical and thermal stress conditions which would exist in a coal-fired commercial power plant. The test demonstrated that electrode lifetimes of up to 8000 hours are possible (Figure 2). This result meets a utility industry requirement for early commercial MHD power plants. Electrodes are the elements of the channel which draw off the electricity and are the most critical part of the MHD generator. The 1000-hour test also represented a major advance in Avco Everett's long duration MHD generator experience, following successful completion of tests of 100 hours in 1976 and 500 hours in 1978 (Figure 3).

With respect to enthalpy extraction, the Arnold Engineering and Development Center (AEDC) has achieved performance levels of 10.5% enthalpy extraction with a magnetic field of 3.2 Tesla in preliminary runs of its 290 MW generator.

This result is significant for two reasons. First, it is the latest in a series of experiments, which confirms theoretical predictions for commercial MHD power plant performance; and second, the generator was of large enough size (about half the size of a generator for an early commercial plant) to provide good confirmation of MHD generator scaling laws. Verification of scaling laws has been an important objective of MHD testing, as the relatively small scale generators operated to date cannot achieve the performance projected for larger channel of commercial size. However, as shown in Figure 4, the experimental results

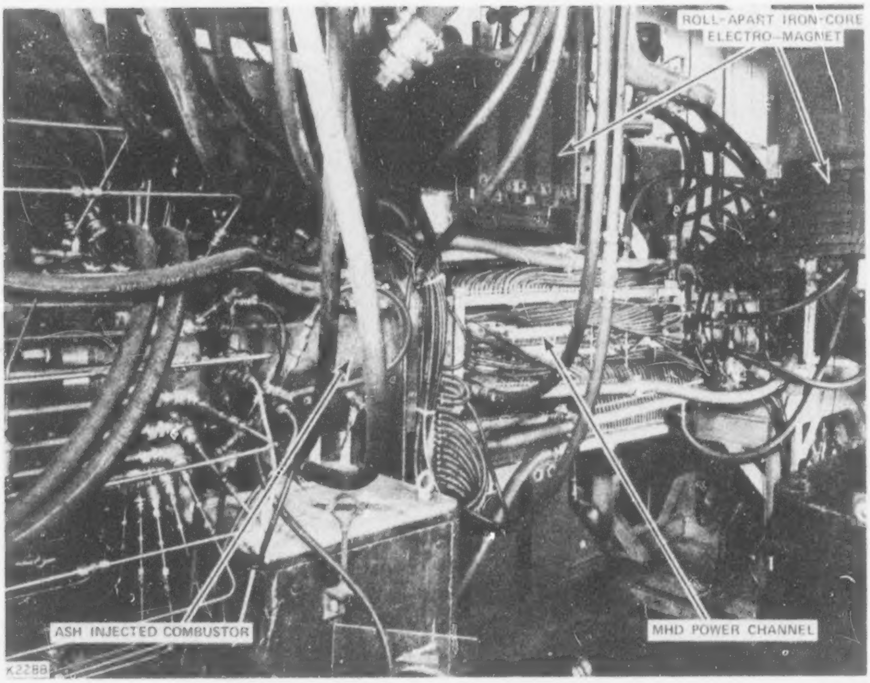
ROLL-APART IRON-CORE ELECTRO-MAGNET
ASH INJECTED COMBUSTOR
MHD POWER CHANNEL
K2288

Figure 1

The 1000-hour test was completed on the Mark VII MHD power train located at Avco Everett, which operates the most extensive industrial MHD test facility in the country.

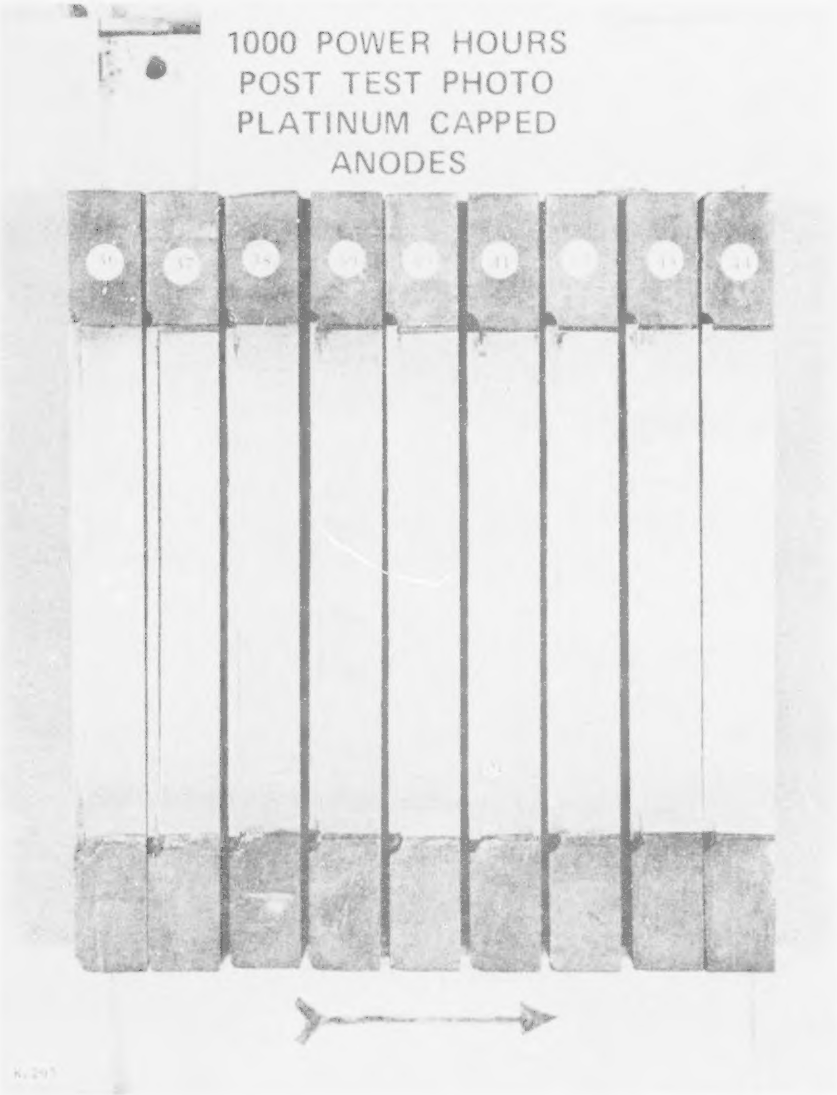
1000 POWER HOURS
POST TEST PHOTO
PLATINUM CAPPED
ANODES

Figure 2

Section of channel wall, showing several electrodes which completed the 1000-hour test at Avco Everett.

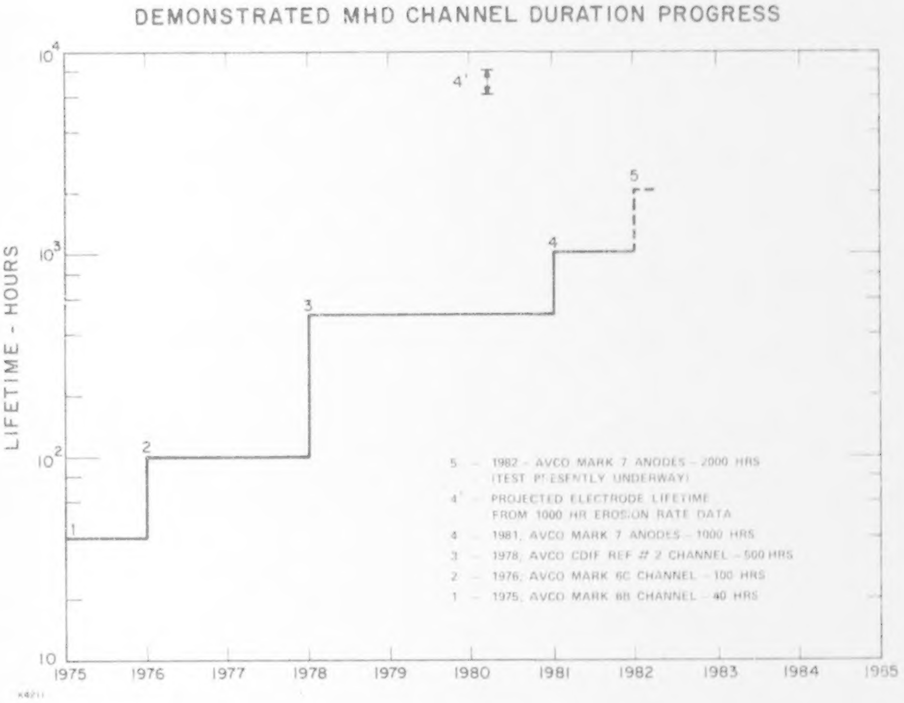
DEMONSTRATED MHD CHANNEL DURATION PROGRESS
LIFETIME - HOURS
10
10^2
10^3
10^4
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1
2
3
4
4'
5
5 – 1982 – AVCO MARK 7 ANODES – 2000 HRS (TEST PRESENTLY UNDERWAY)
4' – PROJECTED ELECTRODE LIFETIME FROM 1000 HR EROSION RATE DATA
4 – 1981, AVCO MARK 7 ANODES – 1000 HRS
3 – 1978, AVCO CDIF REF # 2 CHANNEL – 500 HRS
2 – 1976, AVCO MARK 6C CHANNEL – 100 HRS
1 – 1975, AVCO MARK 6B CHANNEL – 40 HRS
K4211

Figure 3

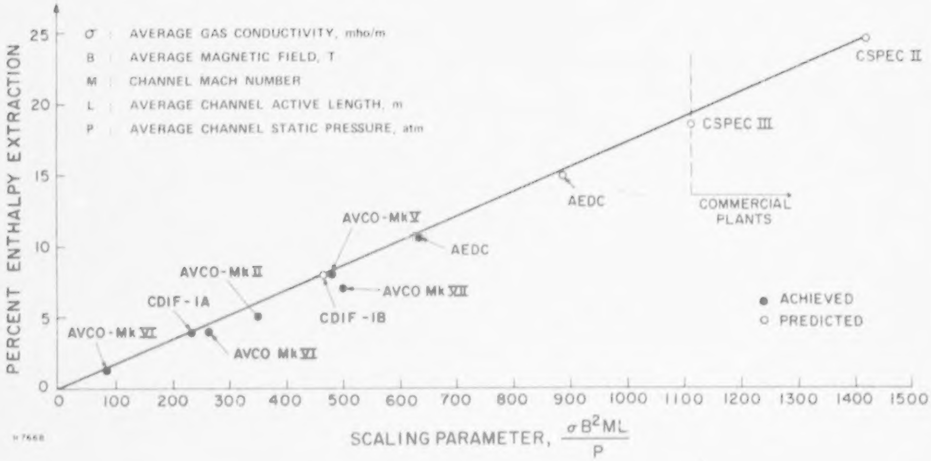
σ : AVERAGE GAS CONDUCTIVITY, mho/m
B : AVERAGE MAGNETIC FIELD, T
M : CHANNEL MACH NUMBER
L : AVERAGE CHANNEL ACTIVE LENGTH, m
P : AVERAGE CHANNEL STATIC PRESSURE, atm
PERCENT ENTHALPY EXTRACTION
0
5
10
15
20
25
CSPEC II
CSPEC III
AEDC
COMMERCIAL PLANTS
AVCO-Mk V
AEDC
AVCO-Mk II
AVCO Mk VII
CDIF - IA
CDIF - IB
AVCO-Mk VI
AVCO Mk VI
● ACHIEVED
○ PREDICTED
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
SCALING PARAMETER, $\frac{\sigma B^2 ML}{P}$
H7668

Figure 4

lie on a line of expected performance which is drawn on the basis of analytical calculations and which leads to performance required for commercial plants.

Coal Combustor

The MHD coal combustor must produce homogeneous, seeded combustion gases at high thermal efficiency as well as withstand the electrical potential of the MHD channel. Two design concepts for the MHD coal combustor have been designed in parallel. The first has been developed by the University of Tennessee Space Institute and utilizes a single stage combustor in which slag is not removed from the combustor. The combustor delivers all the coal mineral matter through the MHD power train to a downstream recovery system in which ash and seed are recovered and separated. The second concept, in which slag is removed from the combustor, has been developed at laboratory scale by three contractors, TRW, Avco Everett and Rocketdyne.

Later this spring, TRW's two stage combustor will be interfaced with an Avco channel at the Avco Everett Research Laboratory to begin actual coal-fired operation of an MHD flow train at the 20 MW level. These tests will provide engineering and performance data for the operational demonstration of a 50 MW power train scheduled for integration tests at the Component Development and Integration Facility (CDIF) in 1983.

Superconducting Magnets

Superconducting magnets for early commercial MHD plants will have a stored energy of between 1000 to 2000 megajoules and will need to provide magnetic fields of 4.5 to 6 Tesla. The technology for such devices is well developed. For example, a fusion experiment superconducting magnet at Livermore Laboratory, which has a more complicated geometry than an MHD magnet, has successfully been operated at a peak field of 7.8 Tesla and has a stored energy of 500 megajoules. Another superconducting magnet presently under construction at Livermore will have a stored energy of 1600 megajoules.

The engineering of superconducting magnets for MHD application has also accelerated in the past year. Argonne National Laboratory in Illinois built and successfully tested a 200 ton s.c. magnet intended for use at the Coal Fired Flow Facility in Tennessee. The magnet generates a peak field of 6.2 Tesla, which exceeds the magnetic field requirement for commercial-scale MHD plants. Also, a 6 Tesla s.c. magnet is being designed and built by the General Electric Company in New York for integrated testing of the power train at the CDIF.

The first successful superconducting magnet for MHD application was built by Avco Everett in 1966. Since then, a s.c. magnet was operated with an MHD channel at the Electrotechnical Laboratory in Tokyo, Japan, and another at the U-25B facility in Moscow. This latter magnet was built by Argonne National Laboratory as part of a U.S.-U.S.S.R. cooperative program, and prdouced a peak central field of 5 Tesla.

Heat Recovery and Seed Recovery

The heat contained in the MHD generator exhaust gas is recovered in a bottoming plant for generation of steam for additional power production and for preheating of the combustion air or oxidizer used for burning of the fuel. In addition to recovery of heat, seed is also recovered in the bottoming plant for economic operation.

The bottoming plant heat and seed recovery system serves also the important function of reducing the content of nitrogen oxides in the gas. NO_x emission control is accomplished by use of two-stage combustion with partial combustion in the MHD combustor and completion of combustion in the bottoming plant steam generator. Experimental and analytical work has shown that the NO_x emission level in the gas can be controlled to very low levels which are only a small fraction of current EPA standards.

Seed recovery is combined with removal of sulfur from the gas. This occurs because the potassium seed will react with the sulfur contained in the gas to form potassium sulfate, which condenses on the boiler walls and is removed. Experimental work has demonstrated that essentially complete sulfur removal from coal combustion gases can be achieved in MHD power plants. This will permit MHD power plants to burn coal of any sulfur content with emission control of sulfur oxides produced in combustion of the coal. Very efficient removal of condensed seed and remaining fly ash in the gas has also been experimentally demonstrated. This assures that efficient recovery of seed can be attained and that emission of particulates is controlled and reduced to levels below EPA standards.

Component Demonstration and Integration

Two government owned, contractor operated test facilities have been commissioned and are presently conducting integration tests of the MHD components supplied by industrial contractors from across the country.

The Component Development and Integration Facility (CDIF) located in Butte, Montana is a complete 50 MW MHD power train test facility. Shakedown tests of an MHD generator supplied by Avco Everett have met design power performance using an ash-injected combustor also supplied by Avco. An EPRI sponsored DC/AC Inverter subsystem is being installed, on schedule, for operational tests in which power will be delivered from the MHD channel to the Montana power grid, through the inverter, in the spring and summer of 1982. TRW in California is completing final design of a 50 MW coal combustor and will make delivery before the end of 1982. Operational data from the integration and demonstration tests of the MHD topping cycle will provide the necessary engineering systems data and scaling law verification to permit design and construction of pilot/demonstration plant-sized hardware.

A second government owned, contractor operated test facility is conducting integrated testing of the bottoming cycle of the MHD system, the Heat Recovery and Seed Recovery System (HRSR). The Coal Fired Flow Facility (CFFF) operated by the University of Tennessee Space Institute in Tullahoma Tennessee has successfully operated a 28 MW coal-fired MHD generator and achieved SO_x and NO_x levels well below EPA's new source performance standards. In addition to pollution control, the CFFF has demonstrated the removal of coal ash carried through the generator from the combustor and efficient recovery of the potassium seed for recycling to the MHD generator.

Economics and Environmental Intrusion

Results from comparative analyses of various proposed advanced energy conversion systems have verified the potential attractive use of MHD for coal burning electric utility power generation. Results by General Electric from the well known ECAS(1) and EPRI(2) studies identified open cycle MHD energy conversion systems as the most promising advanced energy systems offering the potential highest efficiency and lowest estimated levelized cost of electricity of all of the advanced coal burning energy systems analyzed by General Electric in those studies. These studies also showed that MHD, in addition to its economic advantage (low cost energy), and conservational advantage (more effective utilization of coal) also offers distinct environmental advantages (less pollutants and heat rejection) compared to conventional technology and other proposed advanced energy conversion technologies.

Summary and Conclusions

Very significant progress was made during the past year in the development of MHD components. A 1000-hour generator test was completed demonstrating that channel electrode lifetimes of up to 8000 hours are possible. This achievement met a requirement of the electric power utility industry for early commercial MHD power plants.

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(1) a. Energy Conversion Alternatives Study--ECAS--General Electric Phase II Final Report, NASA-CR 134949, Vol. II, Part 3, Dec. 1976.

b. "Advanced Power Cycles and Their Potential for Electrical Energy Generation," Fox, G.R., General Electric Company. Proceedings of the American Power Conference, Vol. 40, pp. 464-478 (1978).

(2) "Comparative Study and Evaluation of Advanced Cycle Systems." EPRI AF-664, Project 235-1 Final Report, February 1978.

An MHD coal combustor in which slag is removed has been built and tested and will be used to begin actual coal-fired operation with an MHD channel at the 20 MW level this spring. These tests will provide the data needed to begin 50 MW coal-fired power train testing at the CDIF.

Superconducting magnet technology is well developed and poses no major problems. The heat and seed recovery system and pollution control activity have made important strides this year.

One can therefore conclude with confidence that if properly funded, the technology development now being conducted by DOE's MHD Office will make it possible to begin the commercialization phase of MHD development within the next four to five years.

Senator FORD. Thank you, Mr. Brown and all of the panel members. We came within a couple of minutes of the 30 minutes, and that is unusual. I have some questions, and I would like to spread them around. I have, of course, a very strong personal interest in fossil fuel research and development and am very concerned with the downward turn of the funding of research and development and the high-risk involvement that has to be there in order to be in the best interest of the Nation.

I think the Federal Government should take the leadership rather than if you want to do it on your own and you cannot make it, that is tough. Mr. Yancik, did NCA meet with the Department of Energy and OMB officials during the fiscal year 1983 budget preparation process?

Dr. YANCIK. Senator, we did meet with the Department of Energy people in various settings and we did discuss what we believe to be the priority issues regarding funding for full R&D. With the OMB people, we did not meet except that we have in the past expressed a proper Federal role for the Federal Government and there should be a continuity of research effort.

Senator FORD. Why do you think your arguments were not effective?

Dr. YANCIK. It is difficult to give my personal opinion as to the basis for actions on the part of the administration and the Department of Energy people and OMB officials who finally made the decision. But whatever they were, I think we indicated and the panel indicated, they are very shortsighted.

We need all of the energy fuels that we have in this country and that is what makes this country what it is, a strong industrial power, by having these choices to use whatever fuel is the most optimal to whatever the requirements are.

More specifically, I think that they believe that the fossil energy R&D program, as they said, is distorting the marketplace and they use this rationale to justify their actions.

Senator FORD. Would you repeat that statement please?

Dr. YANCIK. They believe that most of the coal R&D programs are distorting the marketplace.

Senator FORD. How do they comprehend that?

Dr. YANCIK. This was an area we pursued in depth with the various program officials at the Department of Energy, attempting to get the criteria that was used and we were not successful.

Senator FORD. Mr. Lawrence. What reaction did the Department of Energy and OMB have to your criticism of the budget as it was being prepared last fall?

Mr. LAWRENCE. We did also meet with them at length, Mr. Chairman. And I think, as you know and as we have testified in these proceedings many times, there has been a very strong bias over the years in long-term research. It used to be in the range of about 8 to 1 and now it is about 13 to 1.

I think there is a tendency now, particularly, to look upon the accelerated decontrol of new gas prices, which we are on the track of, virtually the National Gas Policy Act, which is certainly doing everything we hoped it would and even the accelerated decontrol, as kind of an ultimate solution to all of the gas supply problems. And it is not.

It is something we need. It is what we need for our conventional lower 48 States' supply, but our AGA, the long-term gas supply projections to the year 2000 have about 50 percent of our supplies coming from supplementals, which would include coal gasification sources and new technolcgy sources and as we get on out into the 21st century, those new technologies will have an increasing contribution.

I think it is just this attitude that the marketplace, as a result of accelerated deregulation, will come solve it and again we maintain that it won't and particularly producers are going to be focusing more and more on conventional drilling, exploration, production, and when you get into the long-term research, you are going to be looking to the gas utility industry. It is regulated. Its research funds are looked at very closely by all of the regulatory commissions and it is in dire need of Federal research to meet these standards.

Senator FORD. What is the natural gas price at which the enhanced gas recovery activities become economically attractive for the private industry to pursue without Federal assistance?

Mr. LAWRENCE. The incentive prices and price formation gas has already made some improvements, what the FERC allows in the tight formation, which is about 150 percent of the 1½ times the 103 price. But I think also there is recognition that some of this is not price sensitive, it is physically sensitive.

So we just need some new techniques to improve getting very tight formation gas to come out at a faster rate and kind of like the National Petroleum Council said, after a very extensive 2-year study of this, some dramatic breakthroughs can be accomplished in the field of research. So it is not all price sensitive. It is very much research sensitive too in tight formations.

Senator FORD. Dr. Lee, you made some interesting statements, and you made a statement that I heartily agree with that dollars are needed to bring alternate sources of energy to the commercial stage, that if we allow the present recommendation of the budget there will be a gap, and that gap will be disastrous.

You also said that 1½ percent, I believe, of the use of crude on the international level, which is approximately 2 million barrels, created a buyer's market rather than a seller's market? I am sure all of you at the table are aware of the tightening of the production from OPEC. Just this weekend a service station dealer, where all of us go, got his first price increase in the last 10 months. I think that OPEC prices have gone from an average of 28 and a few cents to over 32. So we find again that the price of crude is not under the control of this country; it is under the control of a few.

So we find that OPEC has control in our lives as it relates to energy. You also said, and I don't want to be quoting all of your statement, that at the time of the law is the time that we should push forward to develop our energy supply.

Let me ask you this, did anyone in the administration or did you have any input as it related to the present budget, either by the Department of Energy or OMB?

Dr. LEE. Senator, we make our views quite plainly known to all who will listen and if people factor these into their planning, then we see it by the results of their actions. I, as an R&D contractor, we are not privy to the deliberations, nor are we consulted much in any administration on how the energy budget should be handled. But I can tell from the actions that result that there is an unrealistic reliance on this magical marketplace that does not exist here; it does not exist any place in the world. Especially, I think this is a shortsighted attitude when you are involved with the private. It takes time to develop. And when time is necessary to make investment decisions are mixed in with the world, military, political, Falkland Islands, you name it, any of these actions, it is impossible for the private investor to make a decision that will not bear any fruit for 10 years.

His alternative will be to do what he has been doing in the past and get results from conventional avenues that bring in returns on investments in the next 2 or 3 years. And that attitude of looking for the sustained effort in development through the marketplace, I hope is gradually getting through to anyone who is planning an energy policy budget. To answer your question directly, no, we do not get involved in the direct planning of the energy policy budget.

Senator FORD. When we sent the synfuel legislation to the House, it was defeated on both occasions, last time very narrowly. When the Senate received the synfuel legislation it came back as the Defense Production Act. That indicated something that I thought was significant about what the House was thinking.

Dr. Lee, your research needs do not list or you did not mention coal liquefaction. Does that indicate a judgment by you or your firm that coal liquefaction technologies are beyond the research and development stage?

Dr. LEE. No, sir. I find it difficult to talk about the broad interview front without getting down to the specifics that we ourselves are involved with. So all the items that I listed in my testimony are areas that we at IGT are doing some work on.

We at this point are not being sponsored to work on liquefaction of coal. Liquefaction of coal is a very viable avenue and we are developing some of our in-house R&D funds to look at new catalysts, and new efforts that could later on lead to some sponsor work at IGT. My not mentioning the area in no way means that these areas are not important.

I think coal liquefaction is a very important area and as you well know our efforts in coal gasification can lead directly to the producing of liquids from coal to the indirect liquefaction of product through the formation of methanol, for example, and gasoline directly. So even though we are working as an R&D performer, much in the gasification area, the results can be applied to liquifying coal.

Senator FORD. I could ask all of you some additional questions, but I do not want to take too much time. Mr. Webb, in your opinion what will the pending decision to cut the personnel in the fossil energy programs to 100 people in DOE headquarters mean to DOE's ability to manage the programs at the level you have suggested?

Mr. WEBB. Mr. Chairman, I think that those budget cuts that they are proposing in light of the budget of the work proposed for gas-related or the approximately $400 million total for fossil energy means that in fact they will not have the resources in-house to adequately manage and lay out the program plans.

Now, this would not be so severe if they were not simultaneously proposing major reductions in energy technology centers. In the past, I guess, as you are aware, they have transferred the data program management for a lot of those programs for the energy technology centers. My thought is they are proposing to close three of the five centers and significantly reduce the staffing, I believe, in the two centers here in the East.

So the combination of those two probably means delays in actions, procurement action delays, contract action delays and as a result leads to increased costs in program management service.

Senator FORD. There is a little rumor running around, and I am not sure how much you can rely on rumors, that even if we give them the additional funding they will not spend it. They are going to adhere to the program they have submitted of $106 million, total. Even if we would increase the budgetary allowance in this particular field they would not use it. Therefore, it is allowed to lapse and go back to the general fund. We find ourselves in the posture of trying to attempt to go forward in this field and being told almost blatantly that regardless of what you do we are not going to do anything else.

I think I had testimony in the last hearing or two ago where they then admitted reluctantly that if the funding were given they would continue. So we find ourselves at loggerheads based on their proposal. Even the Congress thinks it should go further and do more or continue on the same level.

It makes it somewhat disheartening, even if they are able to acquire the additional funding. Are you and the eloquence of this panel then able to convince the Congress that they should raise the level of expenditures? We find ourselves in that dilemma.

Mr. WEBB. Let me comment on that just 1 second, if I may. I guess the reason I find that so hard to understand is that during the budget discussions last year where we had many discussions with Department of Energy personnel and also OMB because we cosponsored many projects, the Department of Energy for the fossil energy program recommended something over $300 million in their budget submissions to OMB and they even appealed back the entire $305 million amount in the appeal process, which seems like to me says that that is the minimum program consistent with the policy, the national energy policy plan that the Department of Energy really believes is needed.

I mean I understand that there are other budget constraints, but that seems totally inconsistent, the actions they took during the budget process, with what they are now telling you in testimony, sir.

Senator FORD. Let me ask you this very quickly. I see the chairman is here. I am delighted that he can take over. If the Federal Government does not fund these activities, will GRI eventually fund them or are there some that are clearly outside of the scope of your mission?

Mr. WEBB. They are not outside of the scope of our mission. They are clearly some that we will not fund. And primarily those are long-term high-risk projects where we assume DOE is going to take the lead and that is the reason we revised our budget, sir. We will not continue to fund geopressured methane research. We will not continue to fund in-situ coal gasification research. We will not be able to continue research in many of the basic coal gasification areas, such as catalyst materials, components, instrumentation.

So what it means is that you end up with a gap here where the long-term research will not be funded and we are devoting our resources to the near term because that is where we can get co-funding from industry and that is where we have to go due to the market forces driving us today.

So we will not be able to dig up the long-term high risk.

Senator FORD. Even though you have increased your budget by one-third, did I understand your testimony that with the reduction of the Federal budget, it is now being proposed that there will be a 40 percent cut in the overall budget available in your mission area?

Mr. WEBB. Yes, sir. That is correct. If you look at the 1982 GRI budget and DOE budget combined in our joint programs in gas-related research, if you look at what they are proposing in 1983, even with our increase of 40 percent, there still is an overall reduction, sir, with 40 percent in the total resources available.

Senator FORD. All of the panelists so far have discussed near term and long term. What does industry mean by near term and long term as it compares to the governmental near term and long term? What is your perception of that? What does it mean to you?

Mr. WEBB. Mr. Chairman, let me just give you my experience in working with member companies and also industrial firms. We have been unsuccessful in achieving major increases and cofunding in our programs, in any program where within 5 to 8 years there is not some sort of a clear path to commercialization so that there is some sort of a beginning of a payback to the industrial sector.

We have increased our cofunding from about $2.5 million in 1977 to $25 million from industrial firms in the last 4 years. All of that has been in near-term research where they can see that if it is successful then they can start earning the payback in 5 to 8 years.

Now, the Federal Government, I am not sure how they are defining near term and long term, but it certainly seems to be inconsistent with the way firms in times of high interest rates actually look at how they allocate their resources.

Senator FORD. What technologies have reached the marketplace that you have spent funds on gas research and development programs over the last 5 to 8 years? In other words, what have you done for me lately?

Mr. WEBB. There have been three or four things that are beginning to reach the marketplace today that came out of joint programs with DOE and some of them of which we fully funded ourself. Probably the three most promising are the pulse combustion furnace, which is a home space heating device that has demonstrated actually in the field seasonal efficiencies of 92 percent compared with the 60 to 65 percent that are in the marketplace today and those will be mass marketed starting this summer by Lynex Corp.

We worked out an agreement with them where the gas industry gets a royalty payback on each unit sold, so that if the program is as successful as we think it will be, eventually we will be able to pay back to the rate payers the cost of that research through the royalty paybacks.

We have developed and are field testing now a commercial heat pump. The size is such that it looks like that it could provide both the heating and the cooling requirements of commercial size buildings. Those field tests are starting this year.

We also have developed in the industrial sector a ladle preheater with Cadra Corp. working with Camera and Ironworks, which will increase the efficiency of heating these huge ladles that handle molten metal from an efficiency of about 12 percent up to about 55 percent. Twenty-seven of those have already been ordered worldwide. They are in production now. Again, that is a program where we get a payback on each unit sold. When I say we, that is the ratepayer who finances our research, sir, in the gas industry.

We have also been working in some ceramic fiber insulation in large foundry operations. That is being commercialized. We are in negotiation with the manufacturer now to start that.

But all of these are more or less in the near term and they are things that were started in the 1977 and 1978 timeframe. So the clear trend is that there is this 4 or 5 years when industry was willing to get involved and they are not willing to get involved in stuff that is 20 years away, regardless of how important it may be to the national need.

Senator FORD. Mr. Podolny, how much more research work must be performed before your fuel cell will be available on the marketplace?

Mr. PODOLNY. In terms of time or dollars?

Senator FORD. Time and dollars both would be fine, if you can give it to us.

Mr. PODOLNY. I guess the best way to answer you, sir, is the fuel cell is sort of backward in one sense, in that we have demonstrated that we can establish the features for the fuel cell and what it can do for the country in terms of efficiency, conservation, and all of those other factors.

We cannot yet demonstrate that we can manufacture it for a competitive cost with durability and reliability, at least for the initial entry into the marketplace. And that exposure is, I think, the most critical thing in terms of the commercial ventures and the ultimate success.

It is very high risk because I consider it to be the compressed spring problem. It is not easy to do the first part of research to prove principles. It is very difficult to get that last little bit which makes it sensible in terms of commercial reality. We see at least another 5 years of strong support to develop improved materials and processes and understanding, so we can get a clearly competitive piece of equipment.

Senator FORD. We have been hearing, at least since I have been here, the last 5 to 7 years, that this would be in the marketplace soon. Now you are telling me it is going to be somewhat longer. Do you have a year in which you think you will be able to put it in the marketplace?

Mr. PODOLNY. The question is we are not in control. Part of the process is, as someone mentioned here on this panel and you yourself said, the changing of philosophy and policy of the country with respect to what we can or cannot do with respect to energy, type of fuel, fuel use and the state of our economy.

Right now, sir, as you say we try to improve our electric generation in terms of conservation, use of site, environment, cost of capital, the fact is that there is not much increased capacity requirements with the kind of economy you have and we are sort of sitting there waiting and saying when will the economy change, saying we will have to increase our generation capacity or our need for energy.

And the question of when will you get into the marketplace is not so much technical readiness or commercial readiness as it is will the market be ready to accept it. That is an up and down process, because we don't have a long-range national policy.

Senator FORD. I think Dr. Lee stated in a lull is the time we ought to push forward.

Mr. PODOLNY. In technology, but not in times of trying to go out into the commercial marketplace.

Senator FORD. Well, that is one or the other. The development in all facets is important. I would hope that we could get into the posture where we would control the marketplace, instead of some others. Last month's percentage of industrial use was about 71 percent. If we get back to the 95 percent of capacity, we will find OPEC countries back in the driver's seat again with the curtailment that they have implied or are ready to impose now, in addition to their ability to control the price. We will then be back in the position of trying to react again, instead of acting as we should be doing now.

Mr. Brown, what portion of the EPRI budget is devoted to coal-base electrical generation?

Mr. **Brown**. Mr. Chairman, I am not sure I can answer that in detail, but I can get that answer for you. It is my impression that in the past it has not been as much as I, who am interested in the fossil side, would like it to be. Just recently they did sign a rather large agreement with the cool water project. They have, I think, some $60 million or $70 eventually invested in that.

In terms of percentage-wise, that would be a sizable amount of the budget they are now running on. I can get that for the record in more detail. That is a little outside my spectrum.

Senator **Ford**. I would appreciate it if you would.

Mr. Yancik, I am going to ask you one more question, and this will be my final one, Mr. Chairman. You suggested that coal or fossil research go back to what agency?

Dr. **Yancik**. That it go back to the Bureau of Mines, the coal mining and preparation program.

Senator **Ford**. Is that where it was before ERTA?

Dr. **Yancik**. Yes, sir.

Senator **Ford**. We have come full scale, Mr. Chairman. I remember when I was Governor, the greatest thing that ever happened to the energy field was that we organized ERTA. Then we went to DOE. We had a secretary down there that straightened it out, I thought, and got it organized pretty well. He testified that we could only save $3 million and would probably lose that much or more in confusion and in transferring to other departments. Now we are getting it right back to where it was.

There is something about this place that if it is not right, keep on working on it, and when you get it right, then get us something else to do.

[Subsequent to the hearing the subcommittee received the following communication:]

NATIONAL
COAL
ASSOCIATION

COAL

CARL E. BAGGE
President
(202) 463-2647

May 6, 1982

Honorable Pete V. Domenici
Chairman, Subcommittee on Energy
  Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D. C. 20510

Dear Senator Domenici,

At the April 26, 1982, Energy Research and Development Subcommittee hearing on Fossil Energy's proposed FY 1983 budget, Dr. Joseph J. Yancik testified on behalf of the National Coal Association. He was asked a question about a statement in his testimony which recommended that DOE's coal mining and preparation research program be transferred to the Bureau of Mines. We would like to amplify on Dr. Yancik's brief response by providing background information and our reasons for the transfer recommendation. We ask that this letter be made a part of the record of the hearings.

First, I want to make it clear that we are recommending transferring to the Bureau of Mines only the Mining Research and Development Program (FY 1982 Appropriation, $10.992 million) and the Coal Preparation and Analysis Program (FY 1982 Appropriation, $2.880 million) from the Fossil Energy office. When DOE was created, these two programs were combined and managed as one program and only recently split apart by a Fossil Energy reorganization.

Both the mining and preparation programs were transferred from the Bureau of Mines to the Department of Energy when it was created on October 1, 1977. Involved in the transfer were three research facilities with 139 field personnel and a headquarters, plus support staff, of 64. The total number of personnel transferred was 203 with appropriated funds of $62.8 million. The following table provides the breakdown between the two programs.

1130 Seventeenth Street, N.W.
Washington, D.C. 20036-4677
(202) 463-2625

	At Time of Transfer To DOE, October 1, 1977		FY 1982 Status	
	Personnel	Funding	Personnel	Funding
Coal Mining Program	92	$57.8MM	28	$10.992MM
.Headquarters				
.Pittsburgh Lab				
.Carbondale Lab				
Coal Preparation Program	47	$ 5.0MM	33	$ 2.880MM
.Headquarters				
.Pittsburgh Lab				
Support Staff	64	--	--	--
TOTALS	203	$62.8MM	61	$13.872MM

As the data in the above table indicates, both programs have been significantly reduced by Fossil Energy. The proposed budgets for these programs in FY 1983 are $1.0 million for mining, and $2.0 million for preparation, a 95% reduction in funding since DOE assumed responsibility.

When the programs were at the Bureau of Mines, and prior to the creation of DOE, they were integrated with a much larger mining health and safety research program. This latter program continues at the Bureau, having been appropriated $46.750 million in FY 1982.

During the past five years, although DOE and the Bureau of Mines cooperated with each other, the research programs were fragmented because arbitrary and sometimes illogical divisions of objectives and responsibilities had to be made. In the real world of mining and preparation, health, safety, environmental, geological, engineering, and technological parameters co-exist and are integral parts of the total mining process. Productivity and safety are not separate problems. One goes with the other.

As was suggested in NCA's statement, in light of reduced budgets and personnel for both agencies and their mining and preparation programs, it makes good sense to recombine these programs as quickly as possible.

We appreciate your interest in maintaining a proper and effective federal role in coal research.

Sincerely,

Carl Bagge

Carl E. Bagge

cc: Honorable Wendell H. Ford

Senator DOMENICI [presiding]. On that one it might have been right all of the time. Maybe we messed that one up. Senator, I thank you for cooducting the hearing to this point and I am going to set a little time limit on myself, because of the nuclear panel witnesses. At 10:15 this panel will be relieved and we will take the nuclear people.

Senator Weicker has a question that he wants you to answer, Mr. Podolny, and we will leave that and you can answer it as soon as you can. I will just address this first one. Are any of you presently participating with the Assistant Secretary for Fossil Fuel in matters that relate to the transfer of research and demonstration facilities to the private sector? If any of you are, could you give us your perspective on those talks? Are any of you at all involved with the Assistant Secretary that is working on transferring to the private sector research and demonstration facilities?

The record will reflect that none of them are participating.

[Subsequent to the hearing the subcommittee received the following communication:]

IGT
Washington Office

November 17, 1982

Senator P.V. Domenici
Chairman, Senate Research &
  Development Subcommittee
S-402, U.S. Capitol
Washington, D.C. 20510

Dear Senator Domenici:

I would like to clarify for the proceedings transcript, a response to a question asked by you of Dr. Bernard S. Lee, president of IGT, at oversight hearings on DOE R&D earlier this year.

Specifically, you asked "Are any of you presently participating with the Assistant Secretary for Fossil Fuel in matters that relate to the transfer of research and demonstration facilities to the private sector? If any of you are, could you give us your perspective on those talks? Are any of you at all involved with the Assistant Secretary that is working on transferring to the private sector research and demonstration facilities?"

Dr. Lee's misunderstanding of the question, indicated that IGT was not involved in such discussions. However, Dr. Lee should have indicated that there had been correspondence between IGT and Jan W. Mares, DOE Assistant Secretary for Fossil Energy, on February 1, 1982 and February 23, 1982 in which IGT requested that ownership of the U-GAS and PEATGAS (modified HYGAS) pilot plants be transferred from the government to IGT. Both research facilities are located on IGT land and were used extensively for federally funded research and development efforts. For example, in the February 23 letter to Mr. Mares, Mr. Lee wrote:

> "We believe it would be inconsistent with the objectives of the Department of Energy and the national interest to allow this excellent facility to be dismantled. There are very few large-scale development facilities capable of handling solid fuels. The emerging synfuels industry should have this facility available to provide the necessary technical and startup support. We further believe that IGT, which is not-for-profit and dedicated to the advancement of energy technology for the public benefit, can provide the greatest assurance that

Institute of Gas Technology
Headquarters
[illegible]
TELEX 25-6189
Energy Development Center
[illegible]
Washington Office
[illegible]
Affiliated with
Illinois Institute of Technology

> this facility will be utilized effectively. We will continue to explore possible applications of this facility, both with DOE program managers and with industry.
>
> If the government plans to keep this facility, then DOE will have to provide funds for IGT to maintain the facility in an operable condition. If, on the other hand, DOE's plan is to abandon the PEATGAS pilot plant, thereby divesting itself of the maintenance cost of the facility, IGT is willing to assume ownership of the plant. If the plant is turned over to IGT, we would keep it intact as long as its major components remain useable and will make it available to future government- or industry-sponsored programs without charge, as has been the long-established practice at IGT with regard to research equipment abandoned by sponsors.
>
> Please consider this a formal offer for IGT to accept title to the PEATGAS pilot plant facility and then to extend its best efforts to utilize this facility in support of energy R&D for the public benefit."

A similar letter making a similar request concerning ownership of the U-GAS pilot plant was sent to Mr. Mares on February 1, 1982.

Thank you for this opportunity to clarify the hearing record. If you have any questions on this matter, please do not hesitate to phone or write me.

Cordially,

Fred H. Zerkel
Director,
Washington Operations

FHZ/clv

Senator DOMENICI. Mr. Lawrence, you mentioned liquified natural safety research is scheduled for phaseout. We had DOE officials up here and they indicated that was the approach because the private sector was going to take over and it was their job anyway. Could you describe efforts that industry has made in the past or present or is negotiating on, cost sharing in this program.

Mr. LAWRENCE. Yes, Senator. The industry has been involved in primarily safety testing in the China Lake area of southern California for some years. And I think a great deal of data has been accumulated there. I think it is at a point now where the test facilities there are not sufficient to conduct the type of tests that they would like to see move forward.

So I think the rather modest amount of money included in this budget is in two categories. No. 1, about $2 million or perhaps as much as only $1.5 million, which DOE, I think, has money set aside to apply for the accumulation and assessment of all the data that has been obtained at China Lake.

And if that is not done, it just falls through the crack and the results of the past several years will not be used in the future. And the other part of the $5 million or the $3 million is expected to be recouped through the user fees by the private sector, not just by LNG users or the LNG industry, but by many other types of fuel techniques.

And I think there is a feeling that some of these safety tests in particular you do need the Government's imprimatur of objectivity to satisfy some of the critics of LNG safety, even though the safety record in handling LNG has been excellent.

Senator DOMENICI. Mr. Brown, regarding MHD, I know that after describing the long-term research resource need you indicate that perhaps the Synthetic Fuel Corporation could be of assistance in the commercialization. I don't want to be argumentative, but I don't understand that and I can't see how, considering their charter, at least what I know about their charter, they could be of help.

Mr. BROWN. If you look at the language of a lot of this past, Mr. Chairman, it includes MHD as one of the technologies that they are allowed to fund.

Senator DOMENICI. I know that.

Mr. BROWN. That is the only reason I mentioned it. I am not sure whether it will come to that, but that is one of the possibilities.

Senator DOMENICI. So that is only based upon the fact that we said they could and named it.

Mr. BROWN. At this point and time, yes, sir.

Senator DOMENICI. That is almost so far out in the future that they will probably be out of the funding business and be just managing the projects that they would have funded. That would be my guess.

Mr. BROWN. It all depends on if the technology on MHD is allowed to continue establishing its engineering technology, based such that a commercial plant can be done in the next 4 to 5 years. It is conceivable that it is a possibility, but I agree with you that it is on the outside edge.

Senator **Domenici**. I have four more questions and I will have them submitted specifically to four of you and ask that you answer them at your leisure. And unless Mr. Ford has some additional questions, we thank you very much for being with us today. And I apologize for not being with you at the beginning.

I want to thank you all for being here, Mike McCormack, Mr. Walker, Mr. Carey, Dr. Glass, and Mr. Warren Chernock. I think Congressman McCormack is on a tough time schedule, is that correct, and you have to leave?

Mr. **McCormack**. That is correct.

Senator **Domenici**. If you want to make a statement, a detailed statement——

Mr. **McCormack**. I would like to testify, Mr. Chairman.

Senator **Domenici**. Let us proceed. Go ahead.

STATEMENT OF HON. MIKE McCORMACK, A FORMER U.S. REPRESENTATIVE FROM THE STATE OF WASHINGTON

Mr. **McCormack**. Thank you, Mr. Chairman. I want to certainly express my appreciation and I have submitted my testimony for the record and I will speak from it, and with your consent, Mr. Chairman, I have submitted also additional material and a statement by Dr. Steve Dean, president of Fusion Power Associates.

Mr. Chairman, I would like to speak on fusion authorization requests by the administration. I am here speaking on my own right, not representing anyone. As I think you know, I was the author and the prime sponsor in the House of the Magnetic Fusion Energy Engineering Act of 1980. Senator Paul Tsongas, along with you, Senator Domenici, and many other Members of the Senate, were cosponsors of that bill in the Senate, which was passed by a unanimous voice vote in 1980 with only seven dissenting votes in the House.

I have been directly involved with the fusion program since 1973, when I was a member of the Joint Committee on Atomic Energy and I have always been guided by the conviction, and the Congress has always supported us in it, that this Nation could convert the concept of magnetic fusion energy into reality by about the year 2000, if we funded an adequately coherent program of research, development, and demonstration.

This subcommittee and the other committees of the House and Senate have increased funding for magnetic fusion from about $43 million in 1973 to about $393 million in 1981. During the 1970's, we eliminated some unnecessary projects in the fusion program and directed the fusion budget toward the goal of electric energy production at the earliest realistic date. And then in 1980 we passed the Magnetic Fusion Energy Engineering Act.

Mr. Chairman, that act has now been called into question by the administration budget. I want to call your attention to the fact that three blue ribbon committees, each made up of some of the Nation's outstanding scientists, engineers, and corporate executives, agreed that the time has come for this country to move forward with a program of fusion engineering development and materials testing, and the Hirsch panel and the Buchsbaum committee agreed in 1980 that it should be possible to have a fusion electric demonstration plant on the line by about the year 2000.

It was the confidence expressed in these reports and the concurrent successes in plasma physics research that convinced us that we should enact this bipartisan legislation.

It is significant to note that within only a few weeks after the passage of the act, Japan, Russia, and the European Economic Community initiated reviews of their fusion programs, and within a few months all decided to accelerate their programs in quite the same way that we in the United States agreed to accelerate ours.

Unfortunately, Mr. Chairman, the administration budget proposals for magnetic fusion for 1983 ignore, in effect, the law that we enacted, and would have us revert back to a research only policy for fusion, delaying the engineering initiatives called for in the act by 5 to 10 years.

Because of this unauthorized attempt at policy reversal, the United States is already falling behind in this all-important area of energy engineering development.

I submit that the time has come for the Congress to insist that the spirit of the law be followed and that at least a small part of the funding planned for fusion engineering and materials development be approved for 1983. So I encourage you, Mr. Chairman, to increase the authorization level for magnetic fusion research and development for 1983 by 10 percent over the current level for 1982.

This would mean increasing funding from about $455 million where it is today to $501 million for 1983. This, you will recognize, really only compensates for inflation. It is a 10-percent increase and I recommend that this additional $56 million above the administration's request of only $444 million be appropriated as follows: $10 million for the Center for Fusion Engineering. I point out to you, Mr. Chairman, that the CFE was called for specifically in the 1980 act. It is essential to go ahead with the CFE at this time if we are going to have any fusion engineering device on the line by 1990 or even 1995. It must be remembered that there is a tremendous amount of engineering and materials testing required to build such a facility and it must be carefully planned and programed. It cannot be done at the last minute.

This includes engineering that would typically be required for any large project, but also for the unique program of building the engineering facility so that it can be disassembled and reassembled remotely. And also we will use materials that will stand the high flux of the neutrons.

This is an extraordinarily complex challenge and it will require a great deal of preparation.

The CFE is also important in that it will draw in extensive talents of private industry. That is indofusion engineering on a significant scale and at the proper time. I suggest that you continue funding of the fusion materials of irradiation facility.

The FMIT is already partially completed. The basic work on the accelerator has been finished at Los Alamos and a number of component parts are under construction at Hanford. Excavation has begun, it is essentially completed at Hanford, and all detailed design is complete. The FMIT was included as a line item in the 1982 appropriations bill, indicating strong Congressional support in the face of an administration request at that time to delete the project.

It must be remembered that the FMIT will be the only facility of its type in the entire free world and that no fusion device anywhere in the free world which would involve a significant fusion reaction can be built without the information that only the FMIT will provide.

It is also worthy to note that both the European Economic Community and the Japanese Government have indicated an interest in providing financial support for the FMIT, significant support, if the United States will stop equivocating and complete this facility at the earliest date.

I suggest $21 million for the Elmo Bumpy Torus. The contract for the EBT-P at Oak Ridge has already been signed. The machine will be built by the McDonnell Douglas Co. This was included as a line item in the appropriations bill last year after the administration requested that it be deleted.

The concept of the EBT-P combines the best of the Tokamak and the mirror concept. There are many qualified plasma physicists and engineers that believe that when the time comes to build the first power-producing fusion plant, it will be an Elmo Bumpy Torus, rather than either a mirror machine or a Tokamak. It would be folly to abandon such an important project, especially when it is already underway.

Finally, I would recommend $10 million additional for the mirror machine at Livermore. As you are probably aware, $25 million was cut from this budget by the administration this year. This is a large project at Livermore and it is about half completed. To cut back now would delay completion by several years and cost a great deal more money when completed. And delaying the operation of the MFTF-B will also delay access to the scientific information it will provide. This too would be folly.

I should like to emphasize the question of whether or not we are going to have a research only program or a program designed to do something. I should emphasize that the law which the Congress enacted was built on careful consideration of what was necessary to move forward with a successful program of engineering development and materials testing.

It called for a funding level for 1982 of $525 million rather than the $455 million we are spending now. And it called for a 25-percent increase above that $525 million for 1983. These increases originated, Mr. Chairman, in this subcommittee, in your subcommittee 18 months ago. This is a law that you wrote and if it were followed the funding level for 1983 would be $656 million.

I am suggesting $501 million, which means if you accept my recommendation for increases, you will still be below your own recommended funding of 18 months ago by $155 million not counting inflation.

To put this in context, I just want to remind you that the increases that I am suggesting are equivalent to what we pay for 6 hours of oil in 1983. It is also helpful to observe that the fiscal year 1983 budget, the administration budget, proposes large increases for high energy physics, nuclear physics, and basic energy sciences.

So the amount of increase I recommend for fusion should not be the issue. It is simply a matter of priorities.

The Congress committed this Nation to one of the most important projects in its history when it passed the Magnetic Fusion Act. I think the Members of Congress recognized it. They knew it was a 20-year, $20 billion program. They comprehended the extraordinary value to this country and to all mankind of developing this ultimate energy source, at the earliest possible date, for the people of this country and the worlde

Several individuals in the administration who never appear before this committee have taken it upon themselves to undo the fusion engineering program that you and the Congress, supported by scientists and other experts in government and industry, recognize as essential. They are attempting to abrogate the law that you wrote, with disregard to the Congress, specifically directed be done in appropriating funds for the Department of Energy last year.

Senator DOMENICI. That is a pretty serious charge. Do you think they are doing that because of pure fiscal grounds or some other reasons?

Mr. McCORMACK. I believe they are using the fiscal debate, the debate on the budget, as a mechanism to change the program from engineering to research. Why they are doing it, I cannot say. I can only say that some of them opposed the program when it was being passed and that some of them are simply research-oriented individuals.

Senator DOMENICI. Proceed. Thank you.

Mr. McCORMACK. I point out that one spokesman for the Office of Science Technology recently stated in a National Science Foundation hearing, that fusion is perhaps 70 years away; that it is only a research program. Without being qualified to do so, they attempt to arbitrarily ignore and reject what we have done.

Now, I am perfectly well aware, Mr. Chairman, one of the problems facing this Congress is with respect to the budget. I don't ignore these, nor do I pretend they are simple, but I do submit that the challenge with respect to providing an adequate supply of electricity for this country is extraordinarily important.

It must not be ignored, nor can the long leadtimes required to get power on the line be safely ignored. I suggest that you and the members of this Subcommittee on Energy Research and Development can do no less. You are the only ones that can provide the leadership required to emphasize the critical importance of solving our energy problems in spite of the budgetary problems we are facing.

Our energy problems, if they are not solved, will be just as critical to this country in the not too distant future as are the economic and monetary problems we face today.

Mr. Chairman, I repeat, I hope you will sincerely consider the thrust of the budget and the need to stick with the law which you wrote.

[The prepared statements of Mr. McCormack and Dr. Dean follow:]

STATEMENT ON MAGNETIC FUSION ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

By

Hon. Mike McCormack

Good morning, Mr. Chairman.

First of all, Mr. Chairman, I would like to express my appreciation to you and to the Members of the Subcommittee on Energy Research and Development for inviting me today to discuss our nation's policies and programs for magnetic fusion. This is a matter of overwhelming importance for our nation and the world -- especially the world in which our children will live. I hope that I may be of assistance to you, Mr. Chairman, and the Members of the Subcommittee, in your consideration of this matter.

As I think you know, I was the author, and prime sponsor in the House of the Magnetic Fusion Energy Engineering Act of 1980. Senator Paul Tsongas, along with Senators Domenici, Baker, Bradley, Sasser, Laxalt, Matsunaga, Bumpers, Moynihan, Hayakawa, Goldwater, Dole and Huddleston were sponsors in the Senate. This legislation passed by unanimous voice vote in the Senate, and with only seven dissenting votes in the House.

Mr. Chairman, I have been directly involved with the magnetic fusion program since 1973. We have always been guided by the conviction -- and the Congress has always supported us in it -- that this nation could convert the concept of magnetic fusion energy into reality by about the year 2000, with an adequately funded coherent program of research, development and demonstration.

This Subcommittee, and other Committees of the House and Senate, have increased funding for magnetic fusion research from about $43 million in 1973 to about $393 million in 1981. During the late 1970s, we eliminated some unnecessary projects in the fusion program, and directed the fusion budget toward the goal of electric energy production at the earliest realistic date; and in 1980 we passed the Magnetic Fusion Energy Engineering Act.

I call your attention to the fact that three blue ribbon committees, each made up of some of the nation's outstanding scientists, engineers and corporate executives, agreed that the time had come for this country to move forward with a program of fusion engineering development and materials testing, and the Hirsch Panel and the Buchsbaum Committee agreed in 1980 that it should be possible to have a fusion electric demonstration plant on the line by about the year 2000.

It was the confidence expressed in these reports, and the concurrent successes in plasma physics research in laboratories at MIT, Princeton, Oak Ridge, Los Alamos and Livermore (among others) that convinced us that we should enact this bi-partisan legislation.

It is significant to note that within only a few weeks after the passage of the Magnetic Fusion Energy Engineering Act, Japan, Russia and the European Economic Community initiated reviews of their fusion programs, and within a few months all decided to accelerate their programs in quite the same way that we in the United States Congress agreed to accelerate ours.

Unfortunately, Mr. Chairman, the Administration budget proposals for magnetic fusion for FY 83 ignore, in effect, the law that we enacted, and would have us revert back to a "research only" policy for fusion; delaying the engineering initiatives called for in the Act by 5 to 10 years. Because of this unauthorized attempt at policy reversal, the United States is already falling behind in this all-important area of energy engineering development.

I submit, Mr. Chairman, that the time has come for the Congress to insist that the spirit of the fusion law be followed; and that at least a small part of the funding planned for fusion engineering and materials development be approved for FY 83.

I have worked with Mr. Ed Kintner, Former Director of the Fusion Program for the Department of Energy, and Dr. Steve Dean, President of Fusion Power Associates, to analyze the funding levels requested by the Administration for magnetic fusion research and development for FY 83. Based on these studies, I most sincerely encourage you, Mr. Chairman, and the Members of this Subcommittee to increase the authorization level for magnetic fusion research and development for FY 83 by 10% over the current level for 1982. This would mean increasing funding from $455 million for this year to $501 million for FY 83. This, you will recognize, really only compensates for inflation. I recommend that the additional $56 million above the Administration's request of $444 million for FY 83 be apportioned as follows:

- Center for Fusion Engineering $ 10 million (additional)

The CFE was called for specifically in the 1980 Act. It is essential to go ahead with the CFE at this time if we are to have a fusion engineering device on the line by 1990 or even in 1995. It must be remembered that there is a tremendous amount of engineering and materials testing required to build such a facility, and it must be carefully planned and programmed. This includes engineering that would typically be required for any large project, and also for the unique program of building the engineering facility so that it can be disassembled and reassembled remotely. This is an extraordinarily complex challenge and will require a great deal of preparation.

- Fusion Materials Irradiation Facility $ 15 million

The FMIT is already partially completed. The basic work on the accelerator has been finished at Los Alamos, and a number of component parts are under construction at Hanford. Excavation has begun at Hanford and all detailed design is complete. The FMIT was included as a line item in the 1982 Appropriations Bill, indicating strong Congressional support in the face of an Administration request at that time to delete the project. It must be remembered that the FMIT will be the only facility of its type in the entire free world and that no fusion device anywhere in the free world which would involve a significant fusion reaction can be built without the information that FMIT will provide. It is also worthy to note that both the European Economic Community and the Japanese government have indicated an interest in providing financial support for the FMIT if the United States will stop equivocating, and complete this facility at the earliest reasonable date.

- Elmo Bumpy Torus $ 21 million

The contract for the EBT-P at Oak Ridge has already been signed. The machine will be built by the McDonnell Douglas Company of St. Louis. This was included as a line item in the Appropriations Bill for FY 82 after the Administration had requested that it be deleted. The concept of the EBT-P combines the best of the Tokamak concept and the mirror concept. Indeed, there are many qualified plasma physicists and engineers who believe that when the time comes to build the first power producing fusion plant, it will be an EBP rather than either a mirror machine or a Tokamak. It would be folly to abandon such an important project, especially when it is already underway.

- MFTF-B $ 10 million (additional)

As you are probably aware $25 million was cut from the MFTF-B in the Administration budget for FY 83. This is a large project at Livermore and it is about half completed. To cut back on the program now would delay completion by several years, and cost a great deal more money than will be required if the present schedule is maintained. Delaying the operation of the MFTF-B will also delay access to the scientific information it will provide. This too would be folly.

Mr. Chairman, I should like to emphasize that the law which the Congress enacted was built on careful consideration of what was necessary to move forward with a successful program of fusion engineering development and materials testing. It called for a funding level for FY 82 of $525 million rather than the $455 we are spending now; and it called for a 25% increase above the $525 for FY 83. These increases originated, I might add, here in this Subcommittee about 18 months ago. Thus, if the law which you wrote were followed, the funding level for FY 83 would be $656 million. I am suggesting $501 million, which means that if you accept my recommendation, you will still be below your own recommended funding level for FY 83 by $155 million, not counting inflation.

To put this in context, I remind you that we are discussing a program which will provide an unlimited supply of clean energy for all mankind for all time. The increase I recommend for FY 83 is equal to what this country spent every six hours in 1980 for imported oil. The funding level for magnetic fusion for FY 83 is equal to about 2½ days of imported oil; and the entire $20 billion you have projected for fusion research, development and demonstration between now and the year 2000 is less than 2% of what we will spend for imported oil during that time. It is also helpful to observe that the FY 83 Administration budget proposes large increases for high energy physics, nuclear physics and basic energy sciences. Thus, the amount of the increase I recommend for fusion should not be at issue. It's simply a matter of priorities.

Mr. Chairman, Congress committed this nation to one of the most important projects in its history when it passed the Magnetic Fusion Act of 1980. Most of the Members of Congress recognized this when they approved a 20 year, $20 billion program. Most of them comprehended the extraordinary value to this country -- and to mankind -- of developing this ultimate energy source, at the earliest possible date, for the people of this country and the world.

Unfortunately, several individuals in the Administration have taken it upon themselves to attempt to undo the fusion engineering program that we in the Congress, supported by scientists and other experts in government and industry, recognized as essential. They are attempting to abrogate the law that you wrote, and to disregard what the Congress specifically directed be done in appropriating funds for the Department of Energy last year. Administration personnel have only recently stated that fusion is just a research program; and that fusion power is perhaps seventy years away. Without being qualified to do so, they attempt to arbitrarily ignore and reject the deliberations of some of the world's outstanding scientists, as well as of the Congress itself.

Mr. Chairman, you cannot allow this to happen.

I am acutely aware of the colossal problem that is facing every Member of Congress with respect to the budget. The recommendations I make to you are not made in ignorance of projected budget deficits.

Neither do I pretend that there are simple solutions to the problems that you face.

I do submit, however, that the challenge with respect to providing an adequate supply of electricity for this country is extraordinarily important. It must not be ignored, nor can the long lead-times required to get power on the line be safely ignored. I suggest that you who are members of this Subcommittee on Energy Research and Development can do no less than provide the leadership required to emphasize the critical importance of solving our energy problems in spite of the budgetary problems we are facing. Our energy problems, if they are not solved, will be just as critical to this country in the not too distant future as are the economic and monetary problems we face today.

I urge the Members of this Subcommittee to remember the leadership that you provided in 1980 in enacting the Magnetic Fusion Energy Engineering Act of 1980, and to remember that the people of this country are looking to you, now, for the same quality leadership. What you do on this subject during the next few days can have a profound effect upon the world in which your children will live.

ADDITIONAL REMARKS FOR INSERTION IN THE RECORD ON

STATEMENT ON MAGNETIC FUSION ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

By

Hon. Mike McCormack

Mr. Chairman, I was invited to present a paper on the "Implications of Fusion Energy Development" before the January meeting of the American Association for the Advancement of Science. A slightly modified version of that address is attached for insertion in the record of this Subcommittee's proceeding.

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Although there are many important areas of research and development -- not only in fusion but in many other disciplines as well -- it is no exaggeration, I think, to state that magnetic fusion research and development, especially engineering and materials testing, is now at least as important to the people of this nation, and of the entire world, as any other human activity. I make such a statement with full recognition of the importance of many other areas of research in medicine, biology, genetics, electronics, materials and other disciplines. The fact is, however, that the successful demonstration of a practical, economically competitive fusion electric technology will have a truly profound and almost instantaneous impact upon the entire world.

page two.

I am confident that scientific feasibility will be demonstrated in the TFTR and the MFTF-B, as well as such devices as JT 60, JET and a Russian device within the next 3 to 5 years. It was this confidence, and the recognition of the extraordinary potential value to the human race of the development of fusion power that lead the prestigious Fusion Advisory Panel chaired by Dr. Robert Hirsch and the ERAB Panel chaired by Dr. Sol Buchsbaum to idependently conclude in 1980 that the time had come for the United States to move into an aggressive program of magnetic fusion engineering development and materials testing, with the announced goal of building and successfully operating a magnetic fusion electric power demonstration plant by the year 2000. It was the confidence of these two independent panels, each composed of some of the world's outstanding plasma physicists, engineers, research scientists and corporate executives, that this country could succeed in an Apollo-like program to have a magnetic fusion electric power demonstration plant on the line by the year 2000, that generated in us on the House Committee on Science and Technology the conviction that this country should go ahead: that we should compose, introduce and work for the Magnetic Fusion Energy Engineering Act of 1980. It was that conviction that our nation could accomplish the goals set forth in the act that inspired almost unanimous support in the Congress in passing the legislation, in the public in supporting it, and in the Administration in signing it into law.

Setting this nation forth on an intense 20 year, $20 billion program is not a frivilous act. It was undertaken by the leaders of both political parties in the House and Senate, and the Administration after serious consideration of the critical problems this nation faces with respect to providing adequate energy for our people and, at the same time, a recognition of the extraordinary potential that nuclear fusion offers in solving this nation's -- and the world's -- energy problems. It was an act of faith, but it was a serious and deliberate act by responsible leaders of all political, philisophical and economic persuasions. It had almost unanimous support in the Congress of dedicated men and women who concluded that they were, at last, doing something truly worthwhile for this country and for the future. This was an act of statesmanship, deliberation and commitment. It represents the kind of dedication that has made the U.S. a great nation -- and a great people.

The rational for enacting this legislation may be divided into two parts: (1) the critical problems facing this country -- then and today -- with respect to the energy crisis, including the need for a dramatically increased domestic energy production capacity from environmentally acceptable and economically realistic sources; and (2) the limitless source of clean, practical, universally available energy that nuclear fusion offers.

To put the importance of making fusion power available as soon as possible into context, it's necessary to look at the big picture with respect to energy, and then explore the role that fusion will play. This takes us back to the realities of various aspects of the energy crisis. Underlying our concern is the fact that our paramount obligation really is to our country; to its stability, strength and prosperity, and to the freedom, health and continually increasing living standards of our people. Our next concern must be for international stability; for peace, freedom, and higher standards of living for all men and all women everywhere.

This is fundamental, but an adequate supply of energy for the United States and for the other nations of the world is essential to achieving those goals. It is essential for our nation and for our people. An adequate supply of clean cheap energy for all the people of the earth is almost certainly one prerequisite for a chance at world peace.

Our requirements for energy in this country, and for the world, will continue to increase in spite of any conservation program, however spartan and however successful. We will need all the energy we can get, from every realistic domestic source, for as far as we can see into the future. Furthermore, that energy must be as clean, safe and environmentally acceptable; as much as is practical now, and progressively more so with each passing year.

In 1977 President Carter suggested reducing this nation's energy consumption growth rate to about 2% per year between 1977 and the year 2000, thus reducing our total energy consumption from all sources to the equivalent of about 56 million barrels of oil a day in the year 2000 (down from 84 MBOE). President Carter's conservative goal assumed an extraordinarily spartan and successful conservation program, and it assumed a dramatic reduction in our imports of petroleum.

However, the people of this country, and their leaders, seem to have forgotten the energy crisis and the very real hazards that we face because of it. Our dependence on imported oil, and the economic, political and military vulnerability that results from that dependence is the first element of the energy crisis.

In 1981 we imported about 6 million barrels of oil a day, at a cost of about $70 billion and one of the largest trade deficits in history. After all of the political rhetoric about federal spending programs, deficits, inflation rates and tax relief, one fact which is being studiously ignored is that our trade deficits, caused by the importation of oil, are a significant factor in weakening our economy. We continue to be vulnerable to increases in the price of oil -- over which we have no control at all -- and each price increase has resulted in substantial inflationary pressures in this country for months thereafter.

The severe problems associated with the very real political, economic and military vulnerability caused by our continuous dependence on imported oil must be solved in this decade, and it is obvious that fusion energy can make no contribution to solving them. It should be observed, however, that there are programs which, if initiated, could make a significant difference in a relatively short time. In addition to continuing our successes in reducing our consumption of gasoline, we could dramatically reduce the 3 million barrels of oil we burn each day for space heating primarily in residences. This could be accomplished by installing instead heat pumps. They -- and the electricity they use -- would be cheaper over the long run for the homeowner than the oil they burn. Also, we can reduce the amount of oil still being used to produce electricity -- more than a million barrels a day, much of it for base load electricity. This is a scandal, and as much as anything betrays this country's unwillingness to face up to the first problem of the energy crisis.

In the longer run, with batteries perhaps twice as good as the present "top of the line" lead acid batteries, practical electric vehicles could be used as service vans and for commuting. They would be cheaper, far cleaner, quieter and completely practical for this use. By the end of the century, if 25% of our automobile fleet were electric vehicles, we would be saving about one and a half million barrels of oil a day, and U.S. manufacturers might regain their share of the auto market.

The second element of the energy crisis involves the need for adequate energy production capacity from realistic domestic sources -- to allow economic stability and adequate standards of living and national defense during the next 25 years. The 1980 Venice conference of Western leaders concluded that about 90% of the new energy generated between now and the end of the century must come from coal and nuclear fission. This is true for this country as well as the world in general. Other energy sources, including hydroelectricity, solar and geothermal energy and energy obtained from the burning of wood or the conversion of organic materials to useful fuels and energy would, in sum, produce no more than about 10% of our energy requirements during the next two decades.

If, in the U.S., we are to reach the production level set by President Carter's conservation goals, it will still be necessary to produce between 30-35 million barrels of oil equivalent from coal and nuclear fission in the year 2000. This is in addition to optimistic projections for energy production from oil, gas, hydroelectricity, solar and geothermal energy, energy from organic materials, etc. Thus, if we more than double our 1980 coal production capacity, it will still be necessary to have between 300-400 GWe of nuclear power on the line by the year 2000. It is obvious that such goals cannot be reached without the implementation of energy policies and programs involving major commitments which are not now contemplated.

This is a national tragedy. Even with spartan and successful conservation programs in all aspects of private life and in the industrial community, a significant decline in the standard of living of the American people, and a reduction in our industrial production capacity is almost certain to accompany our failure to meet our electric energy production capacity requirements. There is an extraordinarily close relationship between electric energy production, GNP and civilian employment in this country, especially since 1974. Although one cannot easily establish a mathematical proof of a causal relationship between Gross National Product and electric energy consumption, a little common sense helps. Most of our major wealth producing, job-producing industries are energy intensive. Many of them are electric energy intensive. It would be irresponsible at best to ignore these extraordinarily close relationships.

If one assumes that demonstration of fusion electricity will occur in the year 2000, then fusion power can have no impact in helping solve this problem between now and the year 2005. If, however, practical fusion power is demonstrated by 1990 by a small privately developed machine such as an OHTE or a Riggatron, then a beneficial impact -- although small in the total energy picture, could occur by 2000. I am optimistic that the Riggatron will succeed in demonstrating a fusion electric power capacity by 1990. Such a small fusion device would be extremely attractive, if one can be made that is technologically and economically feasible.

There are several apparent advantages that make any fusion electric facility potentially extremely attractive. We are all aware of the unlimited supply of cheap fuel, the freedom from fission-product build-up, and the freedom from the generation of large amounts of heat after shutdown. There are two other advantages, however, that merit mention at this time. One is flexibility. Even if small fusion machines (200 MWe or less) prove to be impractical (for any reason), large machines may still be located near, or even within, large cities, thus sharply reducing transmission line requirements. Transmission costs constitute a significant portion of the total cost of electric energy generation and distribution. They are a constant cause of litigation and controversy, and they are vulnerable to sabotage. Elimination of long transmission lines can be a significant advantage for fusion.

With small machines (fusion only -- not hybrids) we can contemplate locating individual generating facilities at various underground sites near load centers or trunk lines within cities, and connecting to the city's distribution system with super-conducting cable. It may also be practical to combine such facilities with super-conducting storage rings for peaking power requirements. Such an advantage for small fusion machines should make them extremely attractive.

There remains the third element of the energy crisis. It relates to environmental protection and to resource conservation. This nation, and the world, must -- as soon as possible -- sharply reduce the burning of fossil fuels to produce energy. This is obviously not possible now, and the rate of reduction will depend on many differing factors in each country. However, it must be our stated goal, if we are to protect our atmosphere from unacceptable levels of pollution, and our world from the Greenhouse effect; and if we are to protect our petrochemical resources from thoughtless depletion. They should be saved for future generations, and we should encourage other nations to accept this philosophy.

In this country, we should plan to limit the use of petroleum products and natural gas for the generation of electricity to peaking power only, and then only when such fuels are the most practical and economical. The use of oil and natural gas for residential heating and hot water should be discouraged, except when it is clearly cheaper and more practical than electricity, electric heat pumps or solar assisted heat pumps and hot water systems, or some combination thereof.

We have no choice but to depend upon coal for the next three or four decades for electric energy production, but this use should be phased out as soon as practical. Until that time, a maximum effort must be mounted to produce clean fuels from coal, and off-gas cleaning systems must be continually improved to reduce air pollution. Of course, it is impossible to know what the actual impact of the Greenhouse effect will be, or when it will appear. Hanging over our heads, however, is the possibility that we will "go over the cliff" without knowing it until it is too late, overload the world's atmosphere with carbon dioxide, and inflict terrible environmental damage on our world, from which it may take centuries to recover.

Our conventional nuclear power industry, backed by a future breeder program is, of course, our mainline protection today against environmental damage from the burning of fossil fuels, but just as doubling our present coal production by the year 2000 will still require having about 400 GWe from nuclear fission on the line by that date, so too will having 400 GWe of nuclear power on line still require us to about double our coal consumption -- or suffer crippling damage to our economy and our standard of living from loss of electric production capacity.

So we must depend upon both coal and nuclear fission until fusion power can begin to make its contribution. When this occurs, and if we can install electric production capacity sufficient for our needs, then we can start phasing out coal plants. Of course, no new coal plants should be started, once fusion power is available.

The implications of a successful program to develop fusion energy cannot, of course, be discussed in a vacuum. Every new energy source or technology must compete in a complex marketplace with all of the others. In addition, significant penetration of the energy market, even by a superior competitor, seems agonizingly slow, even under the best of conditions. Let us assume, for instance, that magnetic fusion electric generation is demonstrated in the year 2000, and that it is, for one reason or another, superior to every other energy source or technology. Let us then assume that, starting in the year 2001, a policy is established that all new energy generating facilities shall be fusion plants. Let us assume also that energy consumption in the United States will be equivalent to 56 million barrels of oil a day from all sources in the year 2000 -- equivalent to about 1850 GWe capacity from plants operating at 33% thermal efficiency and 67% load factor. If we assume only a 1%/yr. growth rate for total energy consumption starting in the year 2000, then our total consumption would be 112 MBOE in the year 2070. If we assume that 75 MBOE of our energy consumption is for electricity in the year 2070, and half of that from fusion, this would require 1250 GWe from fusion, or one new 1 GWe plant on the line each 20 days for 70 years. This schedule does not consider replacement of early fusion plants or the number of small plants required to total 1250 GWe.

Whether or not such a scenario is even remotely realistic may be debated at length, but I suggest that it may prove to be conservative. In addition, it emphasizes why it is so important to move toward a demonstration of practical, competitive fusion power as soon as possible.

There are other aspects of early demonstration that are important to consider. Many of our utilities are almost paralyzed today, failing to plan for the future because of regulatory and economic problems. They find it extremely difficult to plan to build new plants. No new nuclear plants, and only a handful of coal plants, and some of these quite small, have been ordered in three years. Still the demand for electric production capacity continues to grow, and the percent of reserve production capacity dwindles toward brownouts and blackouts. The Electric Power Research Institute predicts that if GNP grows at the rate of 2.5% to 2.9% per year from 1980 to 2000, then electric energy consumption will grow at 3.3% to 4.2% per year during that time. A growth rate of 3% per year would mean doubling in 23 years.

As I have observed, fusion power can make no contribution during this century unless a small machine such as OHTE or Riggatron is demonstrated by the year 1990, and only a small percent by the year 2000, even in that case. However, the demand will be there as soon as fusion power becomes available, and it will be tremendous.

In addition, I believe that demand will grow in foreign nations, including some of the poorer ones, and that the anticipation that fusion power will be available will have a salutory effect on our relations with such nations.

It is interesting to observe that within only a few weeks after our legislation was signed into law in October, 1980, the Japanese reviewed their magnetic fusion program and promptly committed their country to an accelerated schedule for engineering development and materials testing, with goals quite similar to those expressed in our law. The European Economic Community appointed a blue-ribbon review committee even before the end of 1980. By June of 1981, the committee had recommended an accelerated program in engineering development and materials testing, and increased funding to support it.

Unfortunately, both the Japanese and the E.E.C. are dependent on the partially completed Fusion Materials Irradiation Test Facility at Hanford. This is one of the projects that some individuals in the OMB are attempting to kill -- in spite of the fact that it is absolutely critical to our federal program, and is urgently needed by the Japanese and European Community. It is the only such machine in the free world, and the Congress specifically directed in the recently enacted appropriation law for fiscal year 1982 that construction continue.

Now the Administration again proposes to kill the FMIT and the EBT-P. It also is ignoring the directive in the law to move forward with creation of a Center for Fusion Engineering to guide the research and development leading to construction of a fusion engineering test bed (the Fusion Engineering Device) by about 1990, and then a Magnetic Fusion Demonstration Plant by the year 2000.

The refusal of the OMB to comply with the law is, from my perspective, a major tragedy for the world. Not only does it inflict great damage on the federal program, it creates confusion among our foreign friends in Europe and Japan who first followed our lead and relied on this country for cooperative use of partially completed facilities, and who now don't know how to deal with an unreliable ally -- or how to proceed without critical facilities.

Just as important, failure by the Administration to follow the law is disillusioning for scientists and executives of interested industries, and for the young citizens of our nation who looked to the fusion law as a beacon of hope for their future.

I think it is important to recognize that if we bestir ourselves, magnetic fusion power is within the grasp of the human race, and that its potential for benefiting humanity staggers the imagination. I have stated that when we step across that line with the first demonstration of fusion electricity it will constitute the second most important event with respect to energy in human history -- second only to the discovery of fire. The advent of controlled fusion will stand out as a giant step in the march of mankind toward true civilization.

Above all else, fusion is a technology that we can share with every human being in the world. It crosses all political boundaries. Clearly, every single person in the entire world benefits when everyone has the energy he needs, and from that energy, the water and materials that he needs.

Just as fusion is the ultimate source of energy in the universe, so it will be here on earth. When and how this happens is up to us, and the future of mankind, during the lifetimes of our children, will be profoundly affected by what we do now.

Thank you.

FUSION POWER ASSOCIATES

2 PROFESSIONAL DRIVE, SUITE 248 • GAITHERSBURG, MARYLAND 20760

(301) 258-0545

STATEMENT OF
DR. STEPHEN O. DEAN
PRESIDENT
FUSION POWER ASSOCIATES
TO THE
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
OF THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
APRIL 26, 1982

Recommendations

I recommend that the Congress reiterate to the DOE its expectation that DOE implement the engineering initiatives contained in the fusion Act, including the shifting of appropriate responsibility to industry.

A broad program of research and development should be maintained as submitted in the Administration's FY 1983 budget request. In addition to that broad program, however, a small increase in funding would permit maintenance of the engineering initiatives called for in the fusion Act. The increases which I recommend be added, above the Administration's FY 1983 request, are:

- $10M for formation of an industrially-managed Center for Fusion Engineering
- $21M for construction of the EBT-P Project by McDonnell Douglas Astronautics Co.
- $15M for construction of the FMIT Project by Westinghouse at Hanford
- $10M for maintenance of cost and schedule for the MFTF-B Project at Lawrence Livermore National Laboratory

I do not recommend that funds be redistributed from within the existing base programs. Those distributions are best left to the fusion program managers who must carefully balance the scientific and technical merits of many programs, large and small.

I also recommend that funding for inertial confinement fusion be maintained at least at the FY 1982 level and that a reasonable percentage of the funding be spent on developing potential energy applications of inertial confinement fusion.

Fusion Benefits to Society

The astounding changes in living standards of the twentieth century are directly traceable to advances in technology. There is no evidence that the rate of technological innovation has slowed; in fact technological change is

"TO TAKE FROM THE SEA AND TO IMITATE THE SUN" impacting our lives at an ever increasing rate. Looking to the future, history cautions us not to be too presumptuous of our ability to predict it. Who, for example, would have predicted 50 years ago the widespread use of microprocessors and a growing market in personal computers?

A common denominator which underlies modern society is the availability and affordability of energy. Here, many would have us believe that the world is soon to run out of it. Others believe energy is abundantly available and the whole problem is one of economics. Still others believe the energy problem is primarily one of who owns the most easily used resources. The truth is, of course, that all these views are partly correct but not complete and that the true energy problem is a complex one which defies a unique "solution". Predictions of future demand and use patterns, let alone economics, is a fiction of the professional energy analyst. Systematic analysis is worthwhile; but we should not claim any great precision for the resulting forecasts.

Many sources of energy are in use today: fossil (coal, oil, gas, wood), nuclear fission, solar, etc. Each has advantages which result in its use for many applications. Each has its list of difficulties. Coal, for example, is difficult to mine, transport and burn in a safe and environmentally acceptable manner. Many nations of the world have no coal. Oil is now largely controlled by a cartel which has the power to set prices and availability in a way which could destroy economies and be the source of world war. Nuclear fission deployment has spawned unprecedented social resistance and has been regulated to the point where the costs of construction are primarily tied to licensing delays. And so on. Still, each of these sources of energy is playing an important role in today's world. Technological advance does not stand still, however, and we can already begin to see that a new energy source, fusion, will emerge early in the twenty-first century.

Fusion is the energy source of the Sun and stars. It is the combination of hydrogen at high temperature to form helium. Fusion is the opposite of fission, the process in which heavy atoms (uranium, plutonium) are split, releasing energy. For a given weight of fuel, the energy released by fusion exceeds the energy released by fission and far exceeds (by millions of times) the energy released in any chemical reaction (e.g., the burning of coal or oil). Practical amounts of fusion energy will be produced in a fusion power plant.

Fusion takes its primary fuel, deuterium, from the sea and the reaction is so energy efficient that a 1000 MWe power plant can run for a whole year on only one half-ton pickup truck load of fuel. Contrast this with a coal plant of the same size which would require 200 trains of 100 cars each to deliver the coal and a similar number to haul away the ash.

Energy from fusion may be used in many ways to benefit society. For example, fusion may be used to:

- Make electricity.
  - Studies show that the cost of electricity should be roughly comparable to that from other energy sources in the next century. Abundant electricity generated from non-polluting sources would have a major impact on future society, e.g., through the widespread use of electric vehicles.

- o Produce hydrogen
  - Hydrogen may be burned with oxygen (to form water vapor) and used, for example, as a fuel for transportation. It is also an essential ingredient in most synthetic fuel processes.

- o Make fissile material.
  - The neutrons from fusion reactions are efficient producers of fissile material for use in nuclear fission applications. For example, a fusion reactor could produce enough nuclear fuel to supply up to 20 fission reactors of equal capacity.

Other uses of fusion energy include most industrial processes and potentially new chemical and metallurgical processes. In the long-term, fusion may be used as a source of energy for propulsion of space vehicles. It has by far the highest specific impulse of any propellant and is the only known potentially practical way to reach speeds which are required for exploration beyond the solar system.

Environmental Characteristics

As world population and energy consumption inevitably increase, environmental damage (some potentially irreversible) becomes of growing concern. Most of the current resistance to the widespread use of coal and nuclear fission stems from fears of permanent damage to our environment, health or safety. Less widely known is the massive mining of materials which would be required should solar energy systems, as now conceived, be deployed as a baseload energy source for society. Fusion energy should be environmentally and socially acceptable because:

- o There are no combustion wastes.
  - The product of the fusion reaction is helium--a non-toxic, non-radioactive, valuable gas.

- o Radioactivity induced by neutrons in structural materials is in a more benign form than in fission reactors.
  - Calculations indicate that the biological hazard potential from postulated accidents is hundreds to hundreds of thousands of times less than similar postulated accidents in fission reactors.

- o There is no possibility of a runaway nuclear reaction.
  - The fusion process is difficult to initiate and sustain. Any malfunction immediately quenches the reaction.

The mining, milling and transportation requirements for materials are smaller for fusion plants than for other energy sources and there is no requirement for transportation, reprocessing or long-term off-site storage of spent fuel.

Readiness for Accelerated Development

Rapid progress in fusion energy development has occurred in recent years. Success, from a scientific viewpoint, is now assured. Although there remain many difficult engineering problems to be overcome, all have potential technical solutions. This statement applies to both the magnetic fusion program, funded by the DOE Office of Energy Research and to the inertial confinement fusion program funded by the DOE Office of Military Applications.

Industry has played an increasing role in fusion development. Today there are many industries with proven skills to contribute, indeed to provide leadership, to the engineering development phase of fusion. Key areas of industrial expertise include (1) systems design, analysis and management (2) facility construction, component development and manufacture and (3) fusion facility operations. Examples of companies which have experience in these areas are shown below.

Systems Design, Analysis and Management
BDM Corp., Bechtel Group, Black and Veatch Consulting Engineers, Boeing Engineering and Construction Co., Burns and Roe, Inc., Ebasco Services, EDS Nuclear, Inc., Exxon Nuclear, Inc., Gilbert Commonwealth Engineers and Consultants, JAYCOR, W. J. Schafer Associates, Inc., Science Applications, Inc., Stone and Webster Engineering Corp., and TRW

Facility Construction, Component Development and Manufacture
Aydin Energy Division, Combustion Engineering, General Dynamics, Hipotronics, ILC Technology, Maxwell Laboratories, McDonnell Douglas Astronautics Co., Thermo-Electron Corp., United Engineers and Constructors, Universal Voltronics, and Westinghouse

Fusion Facility Operations
Fusion Energy Corp., General Atomic Co., KMS Fusion, Inc., and Mathematical Sciences Northwest, Inc.

The Magnetic Fusion Energy Engineering Act of 1980 sets forth clear goals and timetables for fusion development. Several prestigious review panels have certified the readiness of the fusion program to move into engineering development and their recommendations were incorporated into the fusion Act.

Senator DOMENICI. Senator Ford, do you have any questions of Mr. McCormack? He has to leave.

Senator FORD. One interesting thing that you raised on page 5 of your statement is:

> It is also helpful to observe that the fiscal year 1983 Administration budget proposes large increases for high energy physics, nuclear physics and basic energy sciences. Thus, the amount of the increase I recommend for fusion should not be at issue. It is simply a matter of priorities.

Now, are you suggesting that we cut the budget for those programs?

Mr. MCCORMACK. Mr. Chairman, I hate to have to say this, but if I were in your position and had to amortize the fusion budget and the basic energy sciences budget, the high-energy physics budget and the nuclear physics budget, I would be forced, if I had no other choice, I would be forced to put enough of that money into the fusion program to maintain an engineering development materials testing program, where it belongs.

Senator FORD. Then you are saying you would cut that budget?

Mr. MCCORMACK. I am not saying we should, Mr. Ford. I am saying to put it in the context that you put it, but I am pointing out——

Senator FORD. You put it in that context yourself, I am speaking your words.

Mr. MCCORMACK. I don't mind that. Let me explain, Senator Ford, the same persons who advocate changing the fusion program to research only program are also the ones who are advocating the large increases in these other areas. And this is being done without discussion of the Congress and unless it is called to your attention, the Members of the Congress will not ever be aware of it.

I think we have to decide whether we are going to abandon our energy engineering materials development programs and go with research only across the board.

Senator FORD. Thank you, Mr. Chairman.

Senator DOMENICI. Senator Ford, I think that question you asked is a good one. In fact, what we will ask the staff to do for the record is to list the projects and programs that are contained within that statement. I think we will rather quickly find that it is not as easy to make that kind of prioritizing as one Congressman suggests as a number of those increases are predicated upon utilizing exisiting facilities that would otherwise lose their ability to function or you would be wasting a great investment that you already have unless you increased them some.

Let me just ask one question, Congressman. With reference to the fusion materials irradiation facility, you indicate that we should go ahead and make the commitment, because that might bring in international participation. I wonder if it is not possible to do it the other way. Can we not in some way prove to the administration the significance of this facility proceeding rather than mothballing it by getting foreign commitment?

Mr. MCCORMACK. Mr. Chairman, last July I wrote a letter to the Secretary of Energy with copies to, I am sure there is a copy somewhere in this committee's file. I sent about a 100 copies around the world, suggesting to the Secretary of Energy that he approach the European Community and the Japanese, both of whom have expressed dependence upon the FMIT and ask them to fund 25 percent of the program.

The Secretary acknowledged my letter but has done nothing about it. Subsequently, the Department of Energy personnel have met with the Japanese, at least, to discuss this matter. I don't know whether they met with representatives of the European Economic Community. But I can tell you that your staff will find and you will find that in discussions with the Department of Energy that they will reluctantly admit that that potential for support is there.

So what is missing is the determination by the administration to go ahead with the project at all. And our foreign friends find it frustrating as can be, because it is the only device of its type in the entire free world.

Senator **Domenici**. If we have any additional questions, we will submit them and we would appreciate it if you would answer them as soon as possible. Thank you.

Mr. **McCormack**. I certainly will. Thank you, Mr. Chairman.

Senator **Domenici**. Mr. Walker, chairman of Gas-Cooled Reactor Associates. I understand we are going to try now to have each witness use 5 minutes of their time to give their principal remarks and then we will proceed with questions. If we do this, we may get you all in and the next panel of conservation and renewable witnesses.

STATEMENT OF RICHARD F. WALKER, PRESIDENT, PUBLIC SERVICE CO. OF COLORADO AND CHAIRMAN, GAS-COOLED REACTOR ASSOCIATES

Mr. Walker. Thank you, Senator. I am Dick Walker. I am president of Public Service Co. of Colorado, as well as being chairman of Gas-Cooled Reactor Associates. It is a group of utilities that believes that the helium cooled high temperature gas-cooled reactor system is one of the best fission reactor systems that exists today from efficiency, radiation exposure, and flexibility in some of the things we want to do.

My company is the owner and operator of the Fort St. Vrain facility that uses this concept and it has been run at 100-percent capacity and we are satisfied with it and want to be sure that this technology is available as we move into the second nuclear age.

We have been working with DOE in the past years on lead project development activity, to scale up the size of this kind of a plant, about 2½ to 3 times, to make it possible for steam-coach generation and ultimately heat for processing in different industrial applications.

We have been working with five regional lead project candidates around the country, these are utilities and oil refineries. In the intermountain region where I exist and our company operates the gulf coast region, the mid-Atlantic region, the southeast region and the southwest region. We have worked out strategies and design alternatives for these projects in which the utilities or the private sector would finance about 75 percent of the total cost of the project.

We are looking for the Government to provide some of the front-end design and technology development money, some of the synfuel money and some other assistance maybe in some of the first of a kind projects.

Our recommendation for the 1983 budget includes $40 million to complete the conceptual design and cost estimate and continue technology development to support a startup of the lead project in 1995. Also included is $5 million for advanced HTGR systems, such as the small module HTGR that has been suggested and $3 million for fuel cycle development.

We acknowledge that there are budget restraints. We feel that this concept has so many advantages, both in its present form and in its future form, because of its inherent safety, its licensing margin and plant investment protection, its ease of siting, low radiation exposure to its workers and the flexibile fuel cycle which has thorium and then the opportunity to go to process heat.

We hope that—we have had support from this committee in the past. We much appreciated that and we hope that we can send a strong message to the administration to allow us to continue with this so we can usher in the second nuclear age with a very fine nuclear fission concept.

That is very brief, Mr. Chairman. In the interest of time I will conclude with that recommendation.

[The prepared statement of Mr. Walker follows:]

STATEMENT SUBMITTED FOR THE RECORD

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

FY 1983 BUDGET FOR THE HIGH-TEMPERATURE GAS-COOLED REACTOR PROGRAM

RICHARD F. WALKER
PRESIDENT OF PUBLIC SERVICE COMPANY OF COLORADO
AND
CHAIRMAN OF GAS-COOLED REACTOR ASSOCIATES

APRIL 26, 1982

STATEMENT SUBMITTED FOR THE RECORD
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
FY 1983 BUDGET FOR THE
HIGH-TEMPERATURE GAS-COOLED REACTOR PROGRAM

RICHARD F. WALKER
PRESIDENT OF PUBLIC SERVICE COMPANY OF COLORADO
AND
CHAIRMAN OF GAS-COOLED REACTOR ASSOCIATES

Mr. Chairman and Members of the Subcommittee, my name is Richard F. Walker and I am President of Public Service Company of Colorado and Chairman of Gas-Cooled Reactor Associates (GCRA). I appreciate the opportunity to present Utility/User support for the High-Temperature Gas-Cooled Reactor (HTGR) Program.

Historically, the Utility/User industry has a long record of support for the HTGR and has contributed over $200 million toward the present state of HTGR development. In particular, this support has been instrumental in the design and construction of two HTGR facilities: the Peach Bottom developmental plant that was operated by the Philadelphia Electric Company and the Fort St. Vrain demonstration plant which is currently operating and providing electricity for the Public Service Company of Colorado.

For the past four years, the Utility/User industry, through Gas-Cooled Reactor Associates, has been working with all involved parties within the Government, a broad sector of the nuclear vendor/supplier industry, National laboratories, and foreign HTGR Program participants to establish the HTGR as a viable, commercial energy alternative. In addition to its demonstrated application for highly efficient electricity generation, the HTGR, because of its high-temperature capability, is ideally suited to cogeneration applications with various industrial processes that are presently dependent on fossil energy sources. For all these applications, the evaluated energy cost estimates associated with the HTGR indicate the potential for significant economic savings. Other important attributes are associated with the inherent safety and low environmental impact characteristics of the HTGR. These characteristics result in less reliance on engineered safety systems, added margins for meeting certain licensing criteria, greater siting flexibility, and reduced radiation exposure to plant personnel. Further, given the multibillion dollar investment of central power plants today, the HTGR's inherent safety provides important plant investment protection to both shareholders and rate payers. In our view, therefore, the bases for National support for securing the HTGR as a commercial alternative are compelling.

As you are well aware, financial and regulatory difficulties and reduced growth in many parts of the country have resulted in the deferral or cancellation of numerous generation facilities during recent years. The industry's inability to build new capacity in the near-term implies a strong future demand for replacement and new power plants when the financial and regulatory environments are more receptive. In the interim, it is essential that the Nation maintain the foresight for continuing the development of promising energy alternatives such as the HTGR.

Even in these difficult times we continue to make significant progress. Through GCRA, the Utilities/Users actively continue to develop a Lead Project, guide the associated technical programs and provide overall Program integration support to DOE. Financial support through GCRA for 1981 and 1982 is about $2.5 million per year, including support from EPRI. In addition, the Public Service Company of Colorado which owns and operates the Fort St. Vrain HTGR demonstration plant, has spent approximately $12 million in ~~1982~~ 1981 and has budgeted about $22 million for 1982 for plant improvements that support the continued invaluable demonstration role of this plant.

This year, I am proud to report that the Fort St. Vrain plant achieved 100% power for the first time in early November, 1982. Full-power operation was maintained for about 60 hours to accumulate data before the plant was shut down for a planned maintenance outage. All the plant's systems and components performed at or near design conditions during the full-power test run. Of particular importance, no core temperature fluctuations were observed during the rise to 100% power or during full power operation. In the past, fluctuations, caused by thermal hydraulic redistribution of the flow of helium coolant in the reactor core, have been the basis for the NRC restricting the plant's operation at the 70% power level. However, the recently installed core region constraint devices have resolved this problem. The Fort St. Vrain facility, while operating at 100% of rated reactor thermal power, generated 325 megawatts of electricity and operated at more than 38.5% net efficiency, the highest of any nuclear plant in the U.S.

With regard to fuel integrity and radiation exposure to plant personnel, Fort St. Vrain has had an exceptional operating record. Operating data indicate that the amount of radioactivity carried in the helium coolant has been less than 2 percent of the design limit, demonstrating the structural integrity of the coated fuel particles and the graphite core structure. A comparison of personnel exposure data for Fort St. Vrain and light water reactor plants in the U.S. indicates that Fort St. Vrain had an average annual person-rem exposure rate per GW(e)-year of less than 2 percent of the average exposure rate in light water reactor plants. This low personnel exposure level is even more significant in view of the fact that Fort St. Vrain has virtually unlimited access into the reactor building for all operations and maintenance personnel.

Fort St. Vrain is expected to begin operation this month after a successful maintenance outage and we are hopeful that the NRC will grant approval for continued operation at 100% power. To date, the plant has delivered approximately 3 billion kilowatt-hours of net electrical energy. We are confident that Fort St. Vrain will continue to provide kilowatt-hours and critical confirmation and demonstration of many HTGR concepts. The Public Service Company is pleased to be playing a key role in this effort.

During the past year, both Congress and the HTGR Program participants have recognized that the key to securing the HTGR as a commercial alternative is the establishment of a well conceived Lead Project. This aspect is reflected in last year's Congressional budget guidance language that was initiated by the House Science and Technology Committee. To this end, GCRA and the other Program participants are aggressively addressing and responding to the provisions outlined by Congress. This effort will culminate in June 1982 with a "Lead Project Decision Package" that will provide a sound basis and structure for advancing the Lead Project commitment. The Package is based on the four-loop 2240 MW(t) HTGR Steam Cycle/Cogeneration (SC/C) plant design that has been established as the principal focus of the HTGR Program for the following reasons: (1) the technical feasibility of the system is assured through long-standing design experience and the Fort St. Vrain demonstration plant; (2) relative to the other Project options, the HTGR-SC/C system requires the least resources, involves the least technical risks, and can be deployed on the earliest schedule. Accordingly, this option warrants the greatest private sector financial support; (3) the deployment of the HTGR-SC/C system provides a large fraction of the technology and industrial infrastructure required for the more advanced, follow-on HTGR systems; and (4) the HTGR-SC/C system serves the large electric generation market and is ideally suited for cogeneration with central, baseloaded industrial applications requiring process steam and electricity. Further, with the modular loop concept, the two-loop or six-loop designs may also be applied to meet broad Utility/User power rating needs in the follow-on commercial market.

The Lead Project Decision Package is structured into a series of issue-oriented documents that address the associated technical, financial, and institutional issues that confront all the parties contemplating involvement in such a Lead Project. For example, the Baseline Design and Cost Report defines the plant design and costs, operating characteristics, and construction schedule. Detailed planning documents in the form of a Design and Technology Development Plan and a Licensing Plan define the technical and licensing activities and associated costs necessary to support the deployment of the Lead Project. Further, these planning documents will constitute the basis for managing and controlling such activities. The Lead Project Strategy Plan addresses institutional issues such as Project organization and management, vendor/supplier development, cost/ risk sharing between the private and public sectors, and Project financing.

The development of the Lead Project Decision Package is in concert with the development of multiple Lead Project candidates with specific Utilities/Users. Currently, there are five regional Projects that are under development as potential candidates for a Lead Project as well as follow-on Projects. These are summarized as follows:

1. In the Intermountain Region, my company, the Public Service Company of Colorado, Idaho Power Company, and Colorado-Ute Electric Association would utilize the HTGR-SC/C system to meet new generation requirements. Project evaluation studies during 1981 have established that a Lead Project would be located at or near the Idaho National Engineering Laboratory (INEL) in order to centralize the generation capacity for sharing throughout the Intermountain Region and to utilize the associated resources at INEL. In particular, EG&G could serve as the Project manager and plant operator. Such a Lead Project has the growth potential for a nuclear energy park with associated fuel cycle facilities and cogeneration applications. In addition, such a Lead Project, with appropriate ownership arrangements and fuel cycle modifications, could serve as a supplement or backup to our Nation's military production reactors.

2. In the Gulf Coast Region, Gulf States Utilities and Gulf Oil Refining and Marketing Company have a joint interest in and need for the HTGR-SC/C system to provide electricity to Gulf States' grid and process steam and electricity to Gulf's Port Arthur refinery which currently relies on

gas and oil as a source of energy. In addition, the HTGR plant could serve other large industrial users in this region which has the highest concentration of HTGR applications for central station cogeneration. Ongoing Project evaluation studies are addressing the key issues of energy supply transition for an existing industrial facility, siting and licensing, and ownership/financial arrangements.

3. In the Mid-Atlantic Region, Public Service Electric and Gas, Delmarva Power and Light, and the Philadelphia Electric Company have an interest in and potential need for the future generation and cogeneration application of the HTGR-SC/C system. In the cogeneration application, the HTGR-SC/C system would supply process steam to industrial customers seeking to expand and/or shift from in-house gas and oil reliance or to potentially new industries such as coal gasification. Project evaluation studies during 1981 have identified the cogeneration potential of the HTGR-SC/C system to such applications. Ongoing efforts during 1982 will investigate specific sites and process steam user interests.

4. In the Southeast Region, Florida Power and Light has an interest in the HTGR-SC/C system for future generation capacity at their South Dade site. This site is located in the environmentally sensitive area of Southeast Florida near heavy load centers that are experiencing rapid growth. A siting evaluation was completed during 1981 that quantified and confirmed the siting advantages of the HTGR at this site.

5. In the Southwest Region, Arizona Public Service (APS) also has an interest in the HTGR-SC/C to meet future generation requirements. APS has three large nuclear reactors under construction at the present time. The last is scheduled for operation in 1986. The site at Palo Verde, west of Phoenix, is prepared to receive two additional units and is ideally suited for the HTGR. The critical water situation, siting requirements and expected need for power in the 1995-2000 time period add importance to APS's interest in the HTGR.

In each case, the respective Utilities/Users have an interest in and indicated need for the HTGR-SC/C system to be operational in the mid to late 1990's. Engineering and construction lead times would require commitments within the next few years.

In response to Congressional requests for an indication of utility support for a HTGR Lead Project, I submitted a letter to the House Science and Technology Committee on behalf of the identified Lead Utility/User candidates verifying our continued and genuine intent to aggressively support and ultimately construct an HTGR-SC/C Lead Project. Along with this letter, GCRA submitted the Lead Project Strategy Plan, which is a framework for negotiations between the prospective Lead Project participants.

There are many current issues of economic and regulatory nature that presently confront the utility and nuclear industries. There are also design, technology and institutional requirements for the HTGR-SC/C system that must be met before any party can commit to a Lead Project. The resolution of these requirements has begun and will be advanced with the Lead Project Decision Package.

Regarding the cost-sharing arrangements, it has been GCRA's consistent intent that a private sector entity will support the construction of the Lead Plant to the extent of its commercial value. In addition, the Utility/User industry, through GCRA and EPRI, will support a share of front end costs associated with the Lead Project. The Vendor/Supplier team would share in the risk through firm prices on the plant components and fuel supply, and provide a broadened vendor/supplier base for subsequent HTGR commercial plants. Government financial support is required for the design and technology development of nuclear systems and components, fuel cycle and demonstration, and Project financing support to offset first-of-a-kind costs and risks. As shown in the Lead Project Strategy Plan, our intent is to finance the Lead Project through a cooperative private/public sector effort with industry paying the major fraction, approximately 75 percent, of the total costs.

Regarding government support for FY 1983, GCRA urges the Senate Subcommittee on Energy Research and Development to provide DOE with sufficient funds for continuing to advance the HTGR-SC/C conceptual design and technical programs in support of industry's Lead Project efforts. During FY 1983 we plan to: (a) complete the HTGR-SC/C conceptual design to resolve the remaining design issues and complete major trade-off studies; (b) establish detailed cost estimates and schedules for the Lead Plant; and (c) continue critical-path technology development programs to support the conceptual design and a Lead Plant startup date of 1995. These activities require a minimum budget level of $40 million which includes $2 million for R&D equipment. It is also important to continue support of promising advanced HTGR systems, such as completing the pre-conceptual designs and cost estimates of the smaller scale modular HTGR systems. We recommend $5 million for this effort in FY 1983. Finally, support should continue for the HTGR thorium fuel cycle development. Recommended work in this area consists of spent fuel management for the once-through, low enriched uranium fuel; development of the high enriched uranium (HEU) fuel cycle; and continued work toward fuel reprocessing for spent HEU fuel with emphasis on continuing the cooperative technical programs with the Federal Republic of Germany. These activities will require $3 million in FY 1983.

Mr. Chairman, we clearly recognize the need for budget constraint. However, we believe that our basis for support and the public need are stronger than ever. As we recover from this recession, the need for power will not wait for a delayed program. In addition to the Utility/User progress enumerated before and the identified Utility/User support for a Lead Project, there has been real progress with all elements of the Program. The vendor/supplier support has broadened and strengthened, as reflected by the involvement of General Atomic, General Electric and Combustion Engineering with the Lead Project design and development activities. Support by DOE in structuring the Program to be responsive to the Lead Project technical requirements has been most important. Further, DOE continues to encourage the private sector initiative for the Lead Project as reflected by the language in their FY 1983 budget submittal. In addition, NRC activities are directly responsive to the Lead Project's safety and licensing requirements as reflected in their draft issue of a HTGR Safety Research Program Plan. With continued, strong Congressional support for FY 1983 , we will continue to make real progress toward the realization of the HTGR technology. Thank you for the opportunity to present the Utility/User viewpoint to yur Subcommittee.

Senator **Domenici**. I do have a question. I think in the interest of being fair, I will let the panel go ahead.

Mr. **Walker**. That is fine, Senator.

Senator **Domenici**. You are not on any time schedule. You can wait a few minutes?

Mr. **Walker**. Absolutely.

Senator **Domenici**. Mr. Carey, vice president, government operations, General Atomic Co.

STATEMENT OF NORVAL E. CAREY, VICE PRESIDENT, GOVERNMENT OPERATIONS, GENERAL ATOMIC CO.

Mr. **Carey**. Mr. Chairman, Harold Agnew, our president who wanted to be here today, is traveling overseas and has asked that myself and Tom Johnston, vice president of our fission division in San Diego and Dr. John R. Gilleland, the division director, do the testimony for you here this morning.

We would like to request that the statements that we have submitted, one on fission and one on fusion and an attachment to the fission statement, a detailed statement, be incorporated into the record. And I would like to ask Tom Johnston to open the testimony on the HTGR, sir.

Senator **Domenici**. They will be made a part of the record. You can tell Dr. Agnew that the chairman is very upset that he is not here.

Mr. **Carey**. I presumed he had called to let you know that he was not going to be here, Senator.

Senator **Domenici**. I imagine he has got some very important business.

Mr. **Carey**. He does, Senator.

Senator **Domenici**. Give him my best.

[The prepared statement and additional material submitted by Mr. Carey follows:]

STATEMENT SUBMITTED FOR THE RECORD

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

FY 1983 DEPARTMENT OF ENERGY AUTHORIZATION

HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

NORVAL E. CAREY
VICE PRESIDENT
GENERAL ATOMIC COMPANY

APRIL 26, 1982

Mr. Chairman and Members of the Subcommittee, I am Norval E. Carey, Vice President of General Atomic Company. I appreciate the opportunity to represent the views of my company in support of continued development of the High Temperature Gas-Cooled Reactor.

The High Temperature Gas-Cooled Reactor (HTGR) is an advanced, high efficiency converter reactor system which, in addition to serving the historic role of nuclear power in electrical generation, offers a unique capability to provide high temperature steam and heat to meet the significant needs of the industrial process industries in a cogeneration mode of operation. In addition, the HTGR offers the benefits of the highest safety margins of a nuclear system, along with reduced exposures of operating personnel, lower levels of gaseous, liquid, and solid waste discharge, reduced cooling water requirements, and improved siting flexibility. The HTGR can also serve the defense needs of our nation as a Replacement Production Reactor.

The basic technology of the HTGR has been demonstrated by the operation of the 40 MW(e) Peach Bottom I nuclear plant during the years 1967 through 1974. The 330 MW(e) Fort St. Vrain nuclear station, which successfully reached 100% of design power in 1981, is currently demonstrating key engineering technologies specific to the HTGR. The next stage of development which would establish the basis for commercial deployment of the HTGR is a Lead Plant Project, the prime objective of which is to demonstrate a full scale commercial technology.

The current National HTGR program is focused on the development of the technical, financial and institutional information and commitments required in advance of a decision by the involved parties to proceed with an HTGR Lead Plant. Gas-Cooled Reactor Associates, in their statement before this Committee, will review the overall program activities with particular emphasis on the financial and institutional areas involved in the preparation of a Lead Project Decision Package. They will also identify activities ongoing with specific Lead Project candidates. I will therefore concentrate my testimony on the technical, programmatic, and applications activities.

The technical program activities have placed primary emphasis on advancing the design and supporting technology for the 2240 MW(t) HTGR steam electric/cogeneration plant which serves as a basis for the Lead Project Decision Package. The program is also assessing the capabilities and economics of the HTGR to provide process steam and process heat for industrial applications, particularly the near term applications where the HTGR can generate high temperature (1000°F) steam to substitute directly for fossil energy.

The application of nuclear energy to industrial processes represents a major opportunity to improve the future energy balance and energy economics in the United States. In 1980 over 26% of the U.S. gross energy consumption was in the industrial sector with over 4/5 of that being provided by either natural gas or oil. Detailed studies have shown that 77% of the total industrial heat requirements are at temperatures of 1000°F or less and that about 1/2 are currently delivered to the process in the form of steam. The HTGR has the unique capability to serve most of this market.

Application studies have shown that HTGR steam electric/cogeneration systems integrate easily with major processes including those in the chemical, petroleum, shale oil, tar sands and metal refinery industries, and that the economics are favorable when compared with the other long term alternative - coal. Further, the use of nuclear energy rather than coal will result in reductions in emissions such as SO_x, NO_x, and CO_2, and particulates by from 40 to 100%.

Potential longer term applications involve HTGR reactors with higher operating temperatures. These reactors can serve higher temperature process heat markets such as methane reforming, direct coal gasification, and eventually direct water splitting for hydrogen production. At the higher operating temperatures, the HTGR may also be used to generate electricity using closed cycle helium gas turbines with overall efficiencies of up to 50%.

High Temperature Gas-Cooled reactors, when used for electricity production, offer higher thermal efficiencies (approximately 39%) than the existing LWR technology as well as improved fuel utilization by employing the uranium/thorium fuel cycle. For process steam applications of the HTGR involving the series cogeneration of electricity, overall energy utilization efficiencies of above 90% can be achieved. The HTGR also has inherent safety characteristics; inert helium gas as a single-phase coolant, prestressed concrete reactor vessel, and a massive high-heat capacity graphite core, which combine to significantly reduce both the likelihood of accidents and the potential consequences to the public and facility itself.

The broad potential applications and anticipated benefits from the HTGR has resulted in a major segment of the electric utility industry (acting through Gas-Cooled Reactor Associates) and major oil, gas, process steam users and chemical firms, supporting the development of gas reactors. Through FY'81 private industry has invested over $1 billion to develop this technology. It is the only nuclear program which has received the majority of its development funding from the private sector.

The benefits which can be realized from the HTGR for either electric production or process steam and heat applications has been recognized in West Germany and Japan. Both countries have well established HTGR development programs with 1981 national budgets of $200M and $35M, respectively. A formal agreement exists between the U.S. and the governments of Germany, Switzerland, and France permitting a cooperative program for the development of the HTGR. A number of industry-to-industry agreements are also in place involving the exchange of both technology and personnel. The Japanese have indicated the desire to develop close relationships with the U.S. program and steps have already been taken at the industry level. The common objectives of the West German and Japanese programs and their desire for cooperation provide an opportunity for joint development activities which would benefit all parties.

The impediments to the commercial deployment of the HTGR are rooted in the institutional problems besetting all of the nuclear industry and the need for confirmation of its technical and economic benefits through a Lead Plant Project. The major objectives of the Lead Plant Project include.

(1) Demonstration of full commercial scale HTGR systems and components including features incorporating technology evolution and Fort St. Vrain operational experience.

(2) Establishing the licensing criteria for HTGR systems.

(3) Confirming the incentives of the HTGR nuclear system for electric production and cogeneration.

(4) Establishing a broad industrial infrastructure to support a subsequent commercial HTGR industry.

The Lead Plant Project approach is based on a phased program, with defined milestones. The progress of the program through the several phases preceding the commitment to construction of the plant would require the agreement at each phase by all the participants on the incentives to proceed and on the management, cost and risk-sharing in the next phase.

The Project Definition Phase (FY'81 through FY'83) is focused on the preparation of a decision package for proceeding to Title 1 design. This decision package will provide the plant conceptual design, schedule and cost estimates, Environmental Impact Statement (EIS) and project management plan. During this phase, the lead plant operator/owner and site will be identified. The Preliminary Design Phase (FY'84 and '85) will be devoted to the development of the Title 1 design and the associated licensing effort. The Detailed Design Phase (FY'86 and '87) will provide the final design and issuance of a Construction Permit (CP). Firm priced bids will be available on all major plant components. The successively more detailed cost estimates and schedules, as well as the management and cost sharing plan, will provide the basis for proceeding to the Lead Plant Construction Phase.

The primary responsibility of the government on the program will be to support the development of appropriate technology and first-of-a-kind design, and to establish a framework for government support or incentives which encourage private sector participation. The intent of the financial plan is for the commercial value of the Lead Plant and other program costs, which represent approximately 75% of the total Lead Project costs, to be provided by the private sector.

Substantial progress was made on the Project Definition Phase during FY'81. The reference design was established, significant work on the nuclear system conceptual design was completed, preliminary site-specific studies for candidate utilities were completed, and application studies on oil shale, heavy oil, chemical and refining and synthetic fuel production were prepared.

Base technology development included completion of prioritized design data need packages, selection of reference fuel for LEU-Th fuel cycle, initiation of construction of developmental coater for LEU fuel particles and recommendations for enhanced safety features.

The current FY'82 HTGR steam electric/cogeneration Lead Project activities will result in 60% completion of the nuclear steam conceptual design, completion of preliminary site specific studies for two candidate projects (Gulf Coast refinery/chemical complex, a Southeastern aluminum processing and reduction project) and completion of project decision packages and the preliminary management plan.

FY'82 HTGR base technology development will initiate non-destructive examination of test fuel elements irradiated in the Fort St. Vrain reactor, prepare the test facility for main circulator bearings and seals tests, and initiate air flow tests of upper and lower core plenums.

For FY 1983, GA requests that the House Subcommittee on Energy Research and Production provide budget authority of $48 million (including $2 million for capital R&D equipment) for the HTGR program, broken down as follows:

For HTGR Project and Base Technology	$45M
- Lead Plant Design and Application Studies	$16M
- Base Technology Development	$24M
- Advanced Systems	$ 5M
For Spent Fuel Treatment Program	$ 3M

The requested level of funding in FY'83 will provide for completion of HTGR Lead Plant conceptual design, schedule and cost estimates; completion of the preliminary site review, licensing document and EIS, completion of the management plan; and continuation of site specific studies.

Base technology activities in FY'83 would include the initiation of full-scale core auxiliary heat exchanger tests; the start of main circulator bearing and seal tests; and the confirmation of graphite materials data and the selection of core support structure graphite.

Among the proposed advanced systems activities for FY'83 is the completion of the pre-conceptual design and feasibility assessment of small (approx. 250 MWt) HTGR systems for process steam applications. The spent fuel treatment program would permit completion of the fluidized bed burner off-gas treatment test program and for continuation of Lead Plant spent fuel transportation, storage and processing studies.

The Spent Fuel Treatment Program, funded at $3M in FY'82, with an additional $3M recommendation in FY'83, will allow the ongoing HTGR fuel recycle activities under the leadership of the Oak Ridge National Laboratory to proceed. These activities include the continued operation of the HTGR pilot recycle plant at General Atomic Company.

Oak Ridge National Laboratory, a participant in HTGR technology development for over 20 years, has also proceeded in FY'82 with a major gas reactor test component, the Core Flow Test Facility.

Mr. Chairman, I would ask your permission to submit for the record, along with this statement, a copy of a document entitled "High Temperature Gas-Cooled Reactor Program" which will supplement the information provided in this statement.

Finally, Mr. Chairman, I would like to express our appreciation for the continuing support of this subcommittee for the HTGR program which has made it possible to achieve the technical progress and increased Utility/User support reported on today. I trust that after reviewing this program and the testimony of other program participants, you will be able to support the request for FY'83 funding of the HTGR program.

Thank you for the opportunity of appearing before your subcommittee today.

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DETAILED STATEMENT OF MR. NORVAL CAREY
VICE PRESIDENT, GOVERNMENT OPERATIONS

GENERAL ATOMIC COMPANY
SAN DIEGO, CALIFORNIA

TO THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
SENATE ENERGY COMMITTEE

FY 1983 DEPARTMENT OF ENERGY AUTHORIZATION
MAGNETIC FUSION ENERGY PROGRAM

APRIL 26, 1982

Mr. Chairman, I thank you for the opportunity to present testimony regarding the General Atomic fusion program. I first want to comment on the fusion budget as a whole. Some government officials have been saying that fusion won't be here for fifty or even seventy years. This sort of unwarranted pessimism can easily become a selffulfilling prophecy. If the nation doesn't fund it, it will not be achieved -- fusion will recede into the future, and a future without the freedom from energy strangulation that fusion can provide may well be a bleak one. The community is ready for the transition from the experimental phase to the reactor phase. We have the technology, the organizations, and the expertise in the appropriate disciplines to make that transition smoothly.

We have been enthusiastic supporters of the Magnetic Fusion Engineering Act of 1980. I hope that economic conditions will improve soon, so that we can begin the activities envisioned in the Act. The nation's fusion program could effectively use more funding than you are contemplating here in order to stay competitive within the world fusion program. Given a limited budget, we support the President's budget as a well balanced one. Other witnesses too have spoken about the national fusion program, its progress and its needs. We at General Atomic share their point of view.

I would now like to describe our work at GA and illustrate how it fits into the national program.

General Atomic was the first private industry to engage in fusion research, beginning in 1957. Our fusion program has been supported in recent years primarily through the Department of Energy, but from the beginning it has also received support from the utility industries and from the company itself. This breadth of support is both a result and a reflection of GA's unique position in fusion energy development. We are participants in the very forefront of fusion research, but as an industrial company we concentrate on and are a bridge to the commercialization of fusion power. The cornerstone of our program is Doublet III, currently the largest operating tokamak -- toroidal magnetic confinement machine -- in the world. Doublet III has the goal of approximating the physical conditions in a confined plasma that will be necessary for a fusion reactor.

Two years ago, the Japan Atomic Energy Research Institute joined the Department of Energy in cooperative research on Doublet III. This five-year cooperation represents a strong international endorsement of our program and provides funding for much of the basic hardware fundamental to our long range research plans. This cooperative venture has also resulted in an enhancement of scientific productivity because of the unusual mix of scientific methods and manpower represented by the combination of Japanese and General Atomic scientists. Their collective efforts are resulting in the experimental verification of several theoretical propositions that are important for the future of the tokamak as a viable reactor.

Doublet III is a large tokamak capable of accommodating large, highly-shaped plasmas the size of those planned for Princeton's TFTR and Japan's JT-60. Doublet III is unique in that it combines technical ruggedness with an unusually high degree of technical sophistication and experimental flexibility.

These features of the machine are fully utilized in Doublet III's long-range experimental program plan. This plan may be visualized as having three overlapping, but distinctly discernible, phases. Phase I began in 1978 after the completion of Doublet III slightly ahead of a schedule first set in 1974. Experiments were conducted which emphasized plasma shaping and control in ohmically-heated discharges. During this first phase we verified our ability to make and retain a variety of plasma shapes, confirmed predictions about how well the magnetic bottle will contain plasma heat as a function of its shape and size, and demonstrated methods for prevention of plasma poisoning by impurities. These results added greatly to our confidence in the choice of dee-shaped plasmas for the first-generation tokamak reactor, gave experimental validity to the simplified impurity control schemes adopted for fusion reactor designs, and provided the technical basis for the final phases of experimentation on Doublet III.

The second phase of Doublet III operation recently began in January of 1982 and will continue well in fiscal 1984. During this period increasing levels of the neutral beam heating power will be installed, thus allowing us to heat the plasma well beyond the temperatures attained in Phase I. Initial tests of rf systems for plasma heating and plasma current drive will also be conducted. Particular emphasis will be placed on maximizing beta, a term connoting the relative power density of the plasma. More formally, beta is defined as the ratio of plasma pressure to magnetic field pressure in a fusion device.

Beta values well over 2% have been achieved in Doublet III utilizing only the first of the three neutral beam heaters scheduled for installation. A tokamak reactor is expected to operate with beta values of about 5%. Thus these preliminary results are encouraging, and we believe the additional heating will allow us to reach reactor-like beta values.

Preparations of Phase III have begun. Doublet III's existing vacuum vessel will be replaced by a larger one in late 1984. This will be a relatively easy task, since Doublet III was designed from the beginning to accommodate a new vacuum vessel with a minimum of disassembly and assembly effort. It's larger, dee-shaped plasma should have even better confinement properties and should more closely resemble a reactor plasma in size and operating conditions. A new vessel will allow the high-beta plasma results to be extended to a regime of higher temperature characteristic of a fusing plasma. Engineering problems for reactors design can then be addressed directly.

We thus have a unique opportunity to build and operate a device that fills the need for a large, shaped, high-current, high-beta plasma. Owing to the flexibility of the Doublet III facility, and especially to the demountability of the toroidal field coils, this new stage can be initiated by a straightforward replacement of the present vacuum vessel with a large, dee-shaped vessel. Because of its engineering power and similarity in design philosophy to plans for first-generation tokamak reactors, the modified Doublet III can be the primary program resource for elucidating the properties of a fusion reactor core. Moreover, it will provide an early test bed for future fusion engineering technologies. It is fully complementary to Princeton's Tokamak Fusion Test Reactor, TFTR, which will probe the engineering and physics of a reacting fuel. Together, these two experiments can provide the basis for confident construction and operation of tokamak reactors.

The fiscal 1983 budget contains funding for the new vessel. It represents a highly cost-effective means of constructing a vitally needed tokamak research facility without buying a new operating mortgage.

I hope that this committee, whose interest in the fusion effort has historically been keen and well-informed, shares GA's belief in fusion's importance to the nation. I hope you will continue to be strong supporters of fusion energy.

BRIEFING DOCUMENT
ON

HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM
(HTGR)

PREPARED BY
GENERAL ATOMIC COMPANY

GENERAL ATOMIC

PREFACE

THIS DOCUMENT HAS BEEN PREPARED BY GENERAL ATOMIC TO PROVIDE BACKGROUND MATERIAL ON THE HIGH TEMPERATURE GAS-COOLED REACTOR (HTGR) PROGRAM USEFUL TO DELIBERATIONS ON THE FY-83 NUCLEAR BUDGET. THE HTGR PROGRAM HAS MAINTAINED STRONG USER SUPPORT DURING A PERIOD OF NUCLEAR MALAISE BECAUSE IT CAN UNIQUELY FULFILL A MAJOR ROLE IN THE NATIONAL ENERGY PICTURE, BOTH AS A SECOND GENERATION, SAFER APPROACH TO NUCLEAR ELECTRIC GENERATION AND TO SUPPLEMENT OR DISPLACE FOSSIL FUELS IN PROVIDING HIGH TEMPERATURE ENERGY TO THE PROCESS INDUSTRIES.

THE FY-81 AND FY-82 DOE/INDUSTRY PROGRAM HAS MADE SIGNIFICANT PROGRESS IN ESTABLISHING THE FOUNDATION FOR PROCEEDING WITH AN HTGR COGENERATION LEAD PLANT PROJECT AND IN ESTABLISHING THE TECHNOLOGICAL COMPATIBILITY, ENVIRONMENTAL AND ECONOMIC BENEFITS FOR A NUMBER OF SPECIFIC COGENERATION APPLICATIONS. ALSO DURING THIS PERIOD, THE HTGR HAS BEEN ESTABLISHED AS THE LEADING CANDIDATE TO MEET THE DEFENSE PROGRAM NEED FOR A REPLACEMENT PRODUCTION REACTOR.

THE PROGRAM PARTICIPANTS (INCLUDING THE UTILITY, PROCESS AND SUPPLIER INDUSTRIES) STRONGLY URGE A CONTINUATION OF U.S. GOVERNMENT SUPPORT FOR THE HTGR PROGRAM TO INSURE THE AVAILABILITY OF THIS UNIQUE OPTION AT SUCH TIME AS THE INSTITUTIONAL BARRIERS TO NUCLEAR ENERGY HAVE BEEN OVERCOME.

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HTGR BENEFITS

MULTIPURPOSE ENERGY ROLES

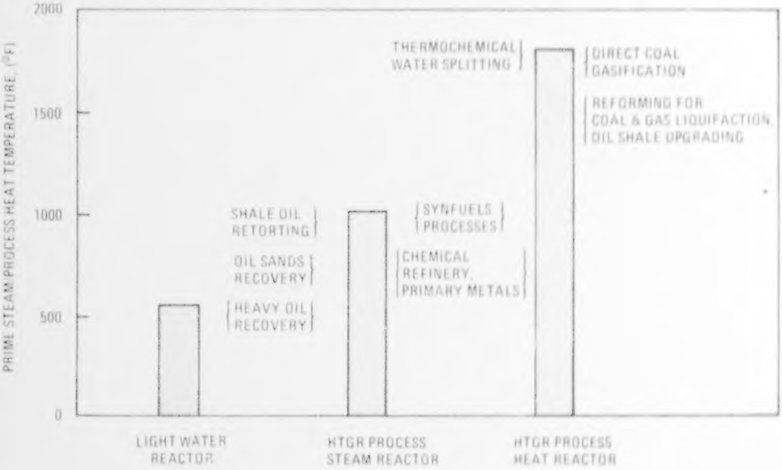
HIGHER PERFORMANCE ELECTRICITY PRODUCTION

- HIGHER THERMAL EFFICIENCY (UP TO 40%)
- REQUIRES LESS URANIUM

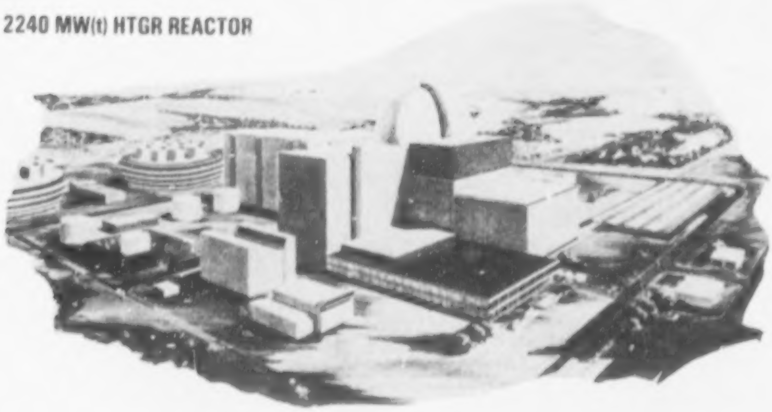
UNIQUE NUCLEAR SYSTEM IN PROVIDING HIGH TEMPERATURE PROCESS STEAM OR HEAT IN COGENERATION APPLICATIONS

- HTGR CAN PRODUCE 1000°F STEAM, COMPATIBLE WITH **57%** OF CURRENT INDUSTRIAL REQUIREMENTS
- CAN DISPLACE FOSSIL FUELS USAGE, REDUCE ENVIRONMENTAL IMPACT
- FUTURE HIGHER TEMPERATURE HTGR PROCESS HEAT SYSTEMS OPEN ADDITIONAL INDUSTRIAL AND SYNFUEL APPLICATIONS TO THE USE OF CLEAN NUCLEAR PROCESS HEAT

CAN CONTRIBUTE TO ALL MAJOR ENERGY DEMAND SECTORS OF THE ECONOMY



2240 MW(t) HTGR REACTOR



OTHER BENEFITS

HIGHER LEVELS OF SAFETY, OPERATIONAL AND ENVIRONMENTAL COMPATIBILITY

- INHERENT SAFETY RESULTS IN MAXIMUM PROTECTION OF PUBLIC AND INVESTMENT, A BASIS FOR IMPROVED PUBLIC ACCEPTANCE
- REDUCED EXPOSURES OF OPERATING PERSONNEL
- LOWEST LEVELS OF GASEOUS, LIQUID AND SOLID WASTE DISCHARGE
- REDUCED COOLING WATER REQUIREMENTS
- IMPROVED SITING FLEXIBILITY

PROGRAM COMPATIBLE WITH POTENTIAL ROLE OF HTGR AS A REPLACEMENT PRODUCTION REACTOR

- ESSENTIALLY ALL NUCLEAR STEAM SYSTEM HARDWARE IDENTICAL

PROGRAM CAN BENEFIT FROM MAJOR INTERNATIONAL HTGR ACTIVITIES FOCUSED IN GERMANY AND JAPAN

STRONG INDUSTRY SUPPORT

CONCEPT HAS CONTINUING SUPPORT OF A MAJOR SEGMENT (OVER 36%) OF THE NUCLEAR UTILITY INDUSTRY AND MAJOR PROCESS INDUSTRIES.

LEAD PLANT PROGRAM DIRECTED TOWARD PRIMARY FUNDING SUPPORT FROM THE PRIVATE SECTOR, DIRECT GOVERNMENT SUPPORT LIMITED TO TRADITIONAL AREAS OF NUCLEAR R & D.

HTGR STEAM CYCLE SYSTEM

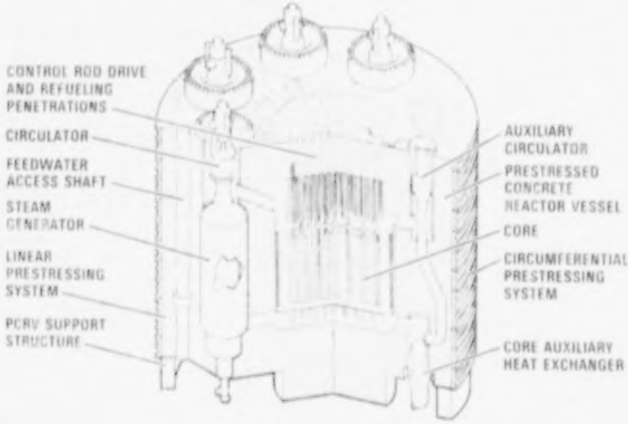
HTGR REACTOR

IN HTGR SYSTEMS, HELIUM GAS IS USED AS THE COOLANT TO REMOVE THE HEAT FROM THE CORE. IN THE HTGR-STEAM ELECTRIC/COGENERATION SYSTEM THE HELIUM IS HEATED TO ABOUT 1280^{0}F. THIS HEAT IS TRANSFERED IN A STEAM GENERATOR TO PRODUCE STEAM FOR PROCESS USE AND/OR ELECTRICITY PRODUCTION. THE ENTIRE PRIMARY SYSTEM INCLUDING STEAM GENERATORS, HELIUM CIRCULATORS, AND AUXILIARY HEAT EXCHANGERS, IS HOUSED WITHIN THE THICK-WALLED PRESTRESSED CONCRETE REACTOR VESSEL. THE FUEL IS CONTAINED IN HEXAGONAL GRAPHITE BLOCKS, SEVERAL THOUSAND OF WHICH ARE STACKED TO MAKE UP THE REACTOR CORE. BECAUSE OF THE SYSTEMS HIGH TEMPERATURE CAPABILITY, SUPERHEATED STEAM CAN BE PRODUCED, CONTRIBUTING TO THE THERMAL EFFICIENCY OF ABOUT 40%, THE HIGHEST OF ANY NUCLEAR PLANT.

STANDARD LOOP DESIGN ALLOWS MULTIPLE UNIT RATING

USING VARYING NUMBERS OF LOOPS, HTGR SYSTEM DESIGNS ARE AVAILABLE IN RATINGS TO MATCH BROAD USER NEEDS.

- 2 LOOP – 1170 MW(t)
- 4 LOOP – 2240 MW(t)
- 6 LOOP – 3360 MW(t)

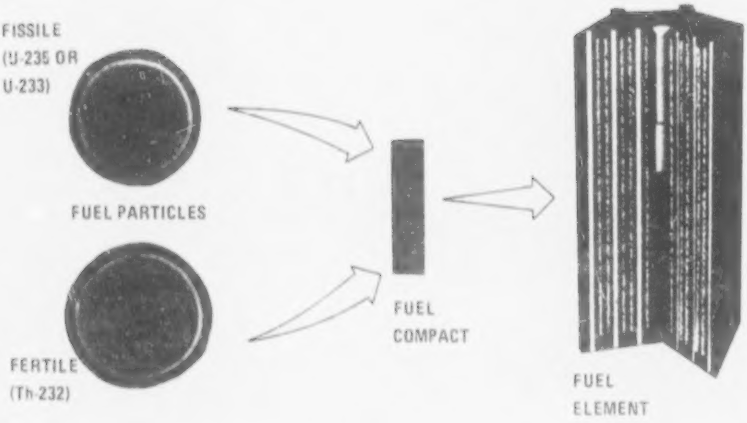

CONTROL ROD DRIVE AND REFUELING PENETRATIONS
CIRCULATOR
FEEDWATER ACCESS SHAFT
STEAM GENERATOR
LINEAR PRESTRESSING SYSTEM
PCRV SUPPORT STRUCTURE
AUXILIARY CIRCULATOR
PRESTRESSED CONCRETE REACTOR VESSEL
CORE
CIRCUMFERENTIAL PRESTRESSING SYSTEM
CORE AUXILIARY HEAT EXCHANGER

SMALL MODULAR DESIGN

SMALL (~ 250 MW(t)) MODULAR HTGR SYSTEMS TO MEET SPECIALIZED REQUIREMENTS ARE UNDER INVESTIGATION

HTGR FUEL

HTGR FUEL IS MADE UP OF TINY SPHERES OF URANIUM AND OF THORIUM, OXIDES OR CARBIDES, EACH OF WHICH IS COATED WITH PYROCARBON AND SILICON CARBIDE, WHICH SERVE TO RETAIN FISSION PRODUCTS. THESE PARTICLES ARE MIXED AND CAST INTO SMALL COMPACTS, (ABOUT 1/2 IN. DIA. X 2-1/4 IN. LONG), AND THE COMPACTS ARE SEALED INTO FUEL CAVITIES RUNNING VERTICALLY THROUGH 31 IN. HIGH HEXAGONAL GRAPHITE FUEL ELEMENTS. THE ACTIVE CORE CONSISTS OF STACKS OF THESE GRAPHITE FUEL ELEMENTS THROUGH WHICH THE HELIUM COOLANT FLOWS IN VERTICAL CHANNELS.



FUEL CYCLE COST ADVANTAGE UNDER COMPARABLE CONDITIONS

- COSTS COMPETITIVE IN STOW-AWAY MODE
- COST BENEFITS INCREASE WITH INCREASING U_3O_8 COSTS AND RECYCLE

EXTENDS U_3O_8 RESOURCE BASE

- USES 25% TO 50% LESS URANIUM THAN LWR DEPENDING ON FUEL CYCLE MODE

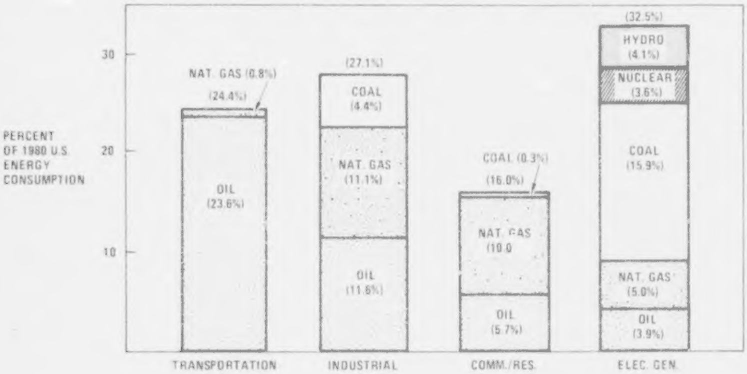
FLEXIBLE URANIUM/THORIUM FUEL CYCLE

- CAN USE EITHER LOW OR HIGH ENRICHED URANIUM CYCLE

CONGENERATION MARKET

OVER 20.6 QUADS (27%) OF THE TOTAL U.S. GROSS ENERGY CONSUMPTION IN 1980 WAS IN THE INDUSTRIAL SECTOR, WITH THE PRIMARY FUELS BEING OIL AND NATURAL GAS. TO AVOID INCREASED PRODUCTION COSTS AND TO MEET PROJECTED GROWTH IN NEW AND EXISTING INDUSTRIAL PROCESSES, INDUSTRY WILL BE FORCED TO TURN TO COAL AND NUCLEAR FOR ENERGY.

U.S. GROSS ENERGY CONSUMPTION IN 1980 – 76.3 QUADS

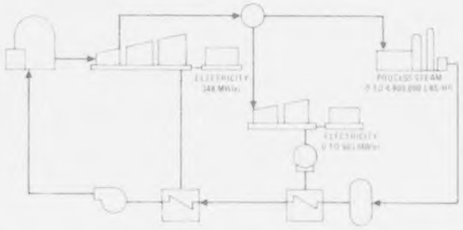


INDUSTRIAL ENERGY REQUIREMENTS

- ABOUT 13.7 QUADS (77%) OF THE REQUIREMENTS ARE AT TEMPERATURES OF 1000°F OR LESS
- ABOUT 9.0 QUADS (44%) OF THE REQUIREMENTS ARE IN THE FORM OF STEAM

PROCESS INDUSTRIES REQUIRE BOTH STEAM AND ELECTRICITY

A VARIABLE HTGR CO GENERATION PLANT CAN ACCOMMODATE MOST INDUSTRIAL APPLICATIONS

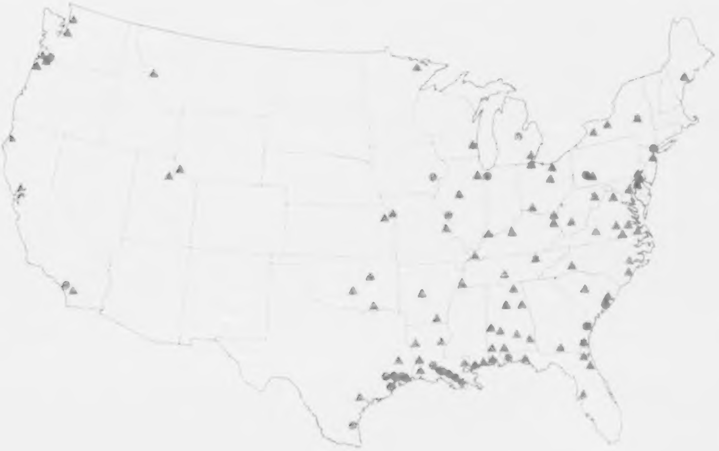


2240 MW(t) VARIABLE COGENERATION PLANT

MARKETS FOR PROCESS STEAM ARE CONCENTRATED

A RECENT DOW CHEMICAL STUDY IDENTIFIED CURRENT LOCATIONS AT WHICH COMBINED INDUSTRIAL STEAM REQUIREMENTS OFFER POTENTIAL FOR THE USE OF CENTRALIZED NUCLEAR PROCESS STEAM

▲ 119 LOCATIONS ≥ 500,000 LB/HR PROCESS STEAM (2 MILE RADIUS)
● 19 LOCATIONS ≥ 4,000,000 LB/HR PROCESS STEAM (10 MILE RADIUS)



A SINGLE 1170 MW(t) HTGR COGENERATION SYSTEM CAN PROVIDE UP TO 2,400,000 LB/HR OF PROCESS STEAM, FROM 175 TO 425 MW OF ELECTRICITY

FUTURE HTGR COGENERATION MARKET POTENTIAL LARGE

DURING THE 2000-2020 TIME PERIOD, THE TOTAL POTENTIAL PROCESS STEAM MARKET HAS BEEN ESTIMATED AT OVER 150 EQUIVALENT HTGR UNITS OF THE 1170 MW(t) SIZE

● MULTIPURPOSE INDUSTRIAL	58 UNITS
● SINGLE USER INDUSTRIAL	50 UNITS
● SHALE OIL PRODUCTION	10 UNITS
● COAL LIQUIDS & SYNTHETIC GAS	25 UNITS
● HEAVY OIL/TAR SAND RECOVERY	8 UNITS

AN ADDITIONAL MARKET WILL EXIST FOR HIGHER TEMPERATURE HTGR PROCESS HEAT SYSTEMS

HTGR COGENERATION APPLICATIONS

TECHNICALLY COMPATIBLE

APPLICATION STUDIES CONDUCTED DURING FY 81, FY 82 IN COOPERATION WITH MAJOR UTILITY & PROCESS INDUSTRIES SHOW THE STANDARD HTGR SYSTEM IS WELL SUITED TO MEET MOST PROCESS STEAM AND ELECTRIC POWER REQUIREMENTS

REDUCED ENERGY COSTS AND LOWERED ENVIRONMENTAL EFFECTS

FOR ALL TYPICAL APPLICATIONS, HTGR COGENERATION SYSTEMS SHOW ENERGY COSTS TO BE REDUCED BY 15 TO 40%, AND EMISSIONS SUCH AS SO_x, NO_x, CO_2, AND PARTICULATES TO BE LOWERED BY 40 TO 100%, WHEN COMPARED WITH COAL FIRED ALTERNATIVES

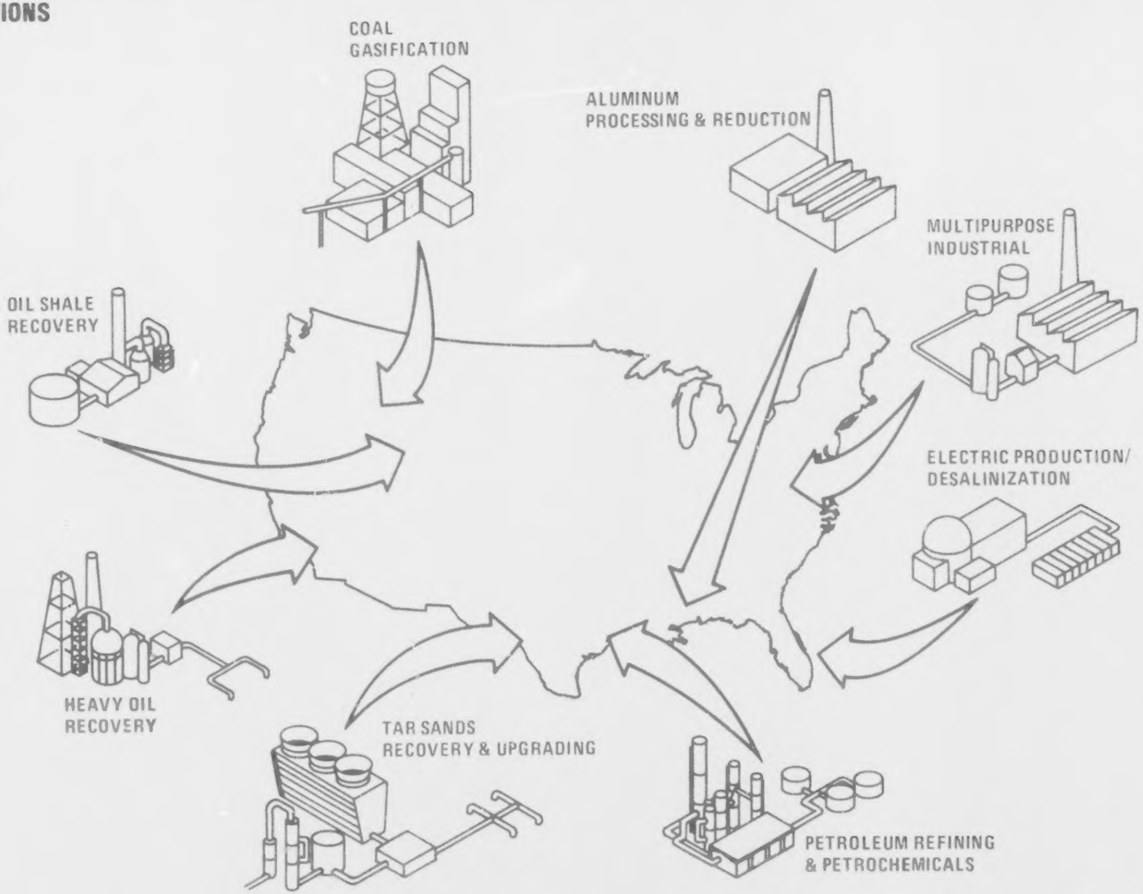
INCREASED ENERGY UTILIZATION

OVERALL ENERGY UTILIZATION INCREASED FROM 40% FOR ELECTRIC POWER GENERATION ONLY TO OVER 90% WITH NUCLEAR COGENERATION, WITH SIGNIFICANT CONSERVATION OF FOSSIL ENERGY RESOURCES.

IMPEDIMENTS TO NUCLEAR PROCESS STEAM ARE INSTITUTIONAL

SELECTION OF NUCLEAR PROCESS STEAM BY INDUSTRIES CURRENTLY DIFFICULT PRINCIPALLY BECAUSE OF INSTITUTIONAL PROBLEMS

- REGULATORY UNCERTAINTIES
- SCHEDULE UNCERTAINTIES
- UNFAVORABLE NUCLEAR CLIMATE
- HIGHER INITIAL COST THAN ALTERNATIVES


COAL
GASIFICATION
ALUMINUM
PROCESSING & REDUCTION
MULTIPURPOSE
INDUSTRIAL
OIL SHALE
RECOVERY
ELECTRIC PRODUCTION/
DESALINIZATION
HEAVY OIL
RECOVERY
TAR SANDS
RECOVERY & UPGRADING
PETROLEUM REFINING
& PETROCHEMICALS

HTGR SAFETY AND ENVIRONMENTAL FEATURES

HIGHER SAFETY LEVEL OF HTGR RESULTS FROM INHERENT PHYSICAL AND NUCLEAR PROPERTIES

- MASSIVE GRAPHITE CORE PROVIDES SLOW TEMPERATURE RESPONSE, DOES NOT REQUIRE FAST ACTING SHUTDOWN SYSTEM
- GRAPHITE CORE AND CERAMIC FUEL STABLE TO EXTREME TEMPERATURES
- NON REACTIVE HELIUM COOLANT
- MASSIVE, REDUNDANT, PRESTRESSED CONCRETE REACTOR VESSEL
- INHERENT SHUTDOWN MECHANISMS (LARGE CORE NEGATIVE TEMPERATURE COEFFICIENT)

INHERENT FEATURES ARE SUPPLEMENTED WITH ENGINEERED SAFETY SYSTEMS

- INDEPENDENT AUXILIARY COOLING SYSTEM
- INDEPENDENT EMERGENCY REACTIVITY SHUTDOWN SYSTEM
- REACTOR CONTAINMENT BUILDING

AMPLE TIME TO RESPOND TO LOSS OF CORE COOLING

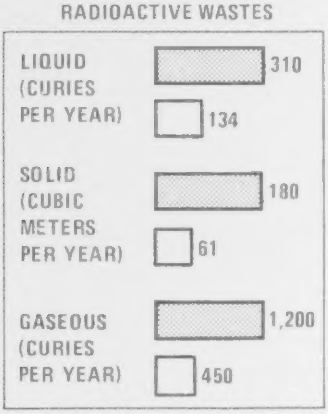
- HOURS INSTEAD OF MINUTES BEFORE DAMAGE TO CORE

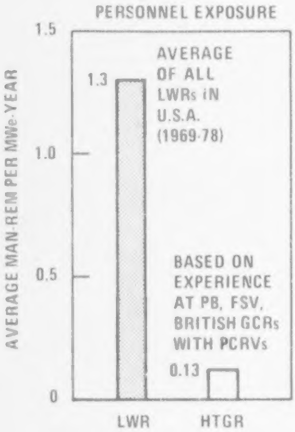
REDUCED RADIOACTIVITY WASTES

HELIUM COOLED HTGR PLANTS INHERENTLY RELEASE INTO THE PLANT PROCESS STREAMS LESS RADIOACTIVITY AND AT LOWER CONCENTRATIONS THAN AN LWR.

SIGNIFICANTLY REDUCED OPERATOR EXPOSURE

EXPERIENCE AT PEACH BOTTOM I, FORT ST. VRAIN AND GAS-COOLED REACTORS IN THE U.K. INDICATE THAT RADIATION EXPOSURES TO OPERATING AND MAINTENANCE PERSONNEL WILL BE ABOUT 1/10 OF THOSE FOR AN LWR.





HTGR ADVANCED SYSTEMS

THE HTGR STEAM CYCLE WILL PROVIDE A TECHNICAL BASE FOR ADVANCED SYSTEMS WITH HIGHER OPERATING TEMPERATURES. TWO SUCH SYSTEMS ARE THE PROCESS HEAT AND THE GAS TURBINE HTGR.

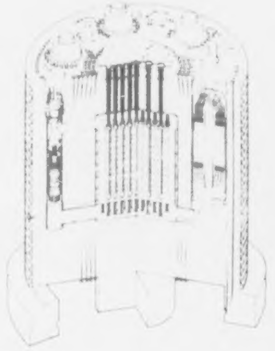
HTGR-PROCESS HEAT

THE PROCESS HEAT HTGR PROVIDES HELIUM CORE OUTLET TEMPERATURES OF 1472° TO 1652°F. AN INTERMEDIATE HEAT EXCHANGER TRANSFERS THE HEAT TO A SECONDARY HELIUM LOOP INCORPORATING A REFORMER THAT CAN BE USED TO REACT STEAM AND METHANE TO FORM HYDROGEN AND CARBON MONOXIDE, A REDUCING GAS THAT CAN BE INTEGRATED INTO SUCH PROCESSES AS OIL SHALE RETORTING, COAL LIQUEFACTION, AND COAL GASIFICATION, TO PRODUCE

- TRANSPORTATION LIQUIDS
- AMMONIA
- SYNTHETIC PIPELINE GAS

AT HIGHER CORE OUTLET TEMPERATURES (1652° TO 1832°F) THE REFORMING REACTION CAN BE PERFORMED MORE EFFICIENTLY AND A DIRECT STEAM-COAL REACTION CAN BE UTILIZED TO PRODUCE

- HIGH BTU GAS
- HYDROGEN (FROM THERMOCHEMICAL WATER SPLITTING)



HTGR-GAS TURBINE ELECTRIC/COGENERATION

THE GAS TURBINE HTGR USES THE HELIUM AS THE COOLANT, AND ALSO AS THE WORKING FLUID WITH AN INTEGRATED DIRECT-CYCLE GAS TURBINE. HELIUM CORE OUTLET TEMPERATURES ARE IN THE 1472° TO 1562°F RANGE. A "BRAYTON" CYCLE IS USED WITH THE GAS TURBINE WHICH RESULTS IN A HIGH WASTE HEAT REJECTION TEMPERATURE (300°F).

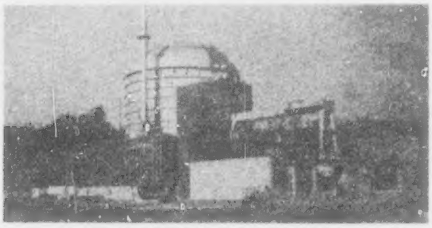
- INTERMEDIATE TEMPERATURE COGENERATION
- ECONOMIC DRY COOLING IN ARID AREAS
- THERMAL EFFICIENCIES TO 50% (WITH BOTTOMING CYCLE)

TECHNOLOGY BACKGROUND

UNITED STATES PROGRAM

SUBSTANTIAL EXPERIENCE, TECHNOLOGY, AND TEST AND MANUFACTURING FACILITIES CURRENTLY EXIST IN U.S.

PEACH BOTTOM UNIT I



40 MW(e) PEACH BOTTOM UNIT 1 HTGR WAS OPERATED SUCCESSFULLY BY PHILADELPHIA ELECTRIC COMPANY FROM 1967 TO 1974, WHEN PLANT WAS SHUT DOWN FOR DECOMMISSIONING AFTER COMPLETING PLANNED DEMONSTRATION PROGRAM.

TEST FACILITIES

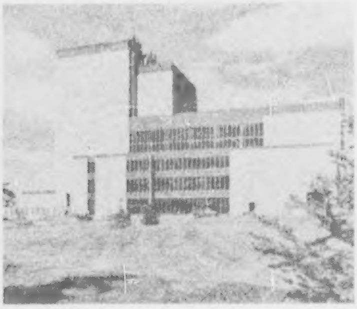
HTGR TEST FACILITY COMPOUND, INCLUDING AIR FLOW TEST FACILITY, COMPONENT TEST TOWER, PCRV MODELS, TENDON TEST FACILITY, PCRV WIRE-WINDING MACHINE, AND HELIUM CIRCULATOR TEST FACILITY.

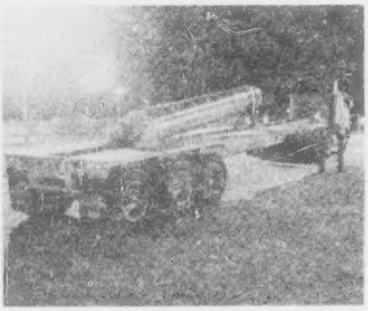
MANUFACTURING FACILITIES

MANUFACTURING FACILITIES AVAILABLE FOR COATED PARTICLES AND FUEL ROD PRODUCTION AS WELL AS SPECIALIZED REACTOR COMPONENTS.

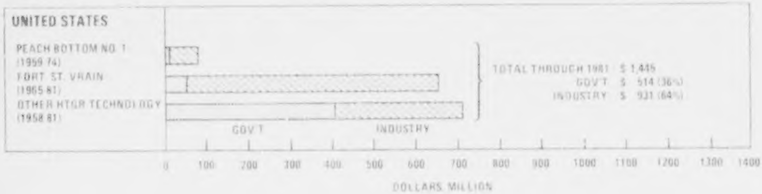
FORT ST. VRAIN

- ACHIEVED 100% POWER OPERATION ON NOVEMBER 6, 1981, FOLLOWED BY 60 CONTINUOUS HOURS OF OPERATIONAL TESTING AT FULL POWER
  - NO CORE FLOW OR TEMPERATURE FLUCTUATIONS OBSERVED DURING RISE TO POWER TESTING OR DURING FULL-POWER OPERATION
  - GENERATED 325 MW OF ELECTRICAL CAPACITY AND OPERATED AT OVER 38.5% THERMAL EFFICIENCY, WITH ONE FEEDWATER HEATER TEMPORARILY OUT OF SERVICE
  - ALL PLANT SYSTEMS AND COMPONENTS PERFORMED AT OR NEAR DESIGN CONDITIONS
- HAS GENERATED OVER 2.5 BILLION KW HRS OF NET ELECTRICAL ENERGY TO DATE
- FUEL PERFORMANCE EXCELLENT, ACTIVITY IN HELIUM COOLANT LESS THAN 2% OF DESIGN LIMIT
- AVERAGE ANNUAL PERSONNEL EXPOSURE RATE SIGNIFICANTLY LESS THAN IN LWR PLANTS, DESPITE VIRTUALLY UNLIMITED PERSONNEL ACCESS INTO REACTOR BUILDING AND ABSENCE OF SECONDARY CONTAINMENT
- DISCHARGED FUEL SHIPPED TO HTGR DRY STORAGE FACILITY AT IDAHO CHEMICAL PROCESSING PLANT





PROGRAM FUNDING THROUGH 1981



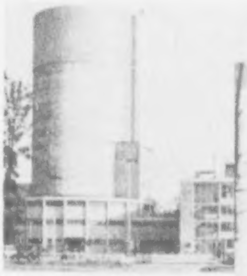
INTERNATIONAL PROGRAM

EXPERIENCE

SUBSTANTIAL INTERNATIONAL EXPERIENCE ON GAS-COOLED REACTOR TECHNOLOGY SUPPORTS U.S. PROGRAM

GERMANY

- AVR - 15 MW(e) HTGR WITH PEBBLE BED FUEL, OPERATED SINCE 1967 STARTUP
- THTR - 300 MW(e) HTGR WITH PEBBLE BED FUEL - CONSTRUCTION 70% COMPLETE - STARTUP PLANNED FOR 1983
- COMPREHENSIVE HTGR PROGRAM WITH STRONG SUPPORT FROM COAL/UTILITY INDUSTRIES
- CURRENT FUNDING LEVEL $200 MILLION

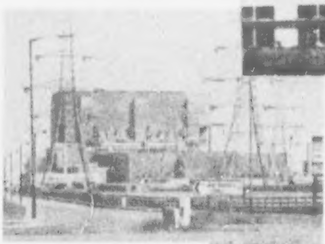


AVR

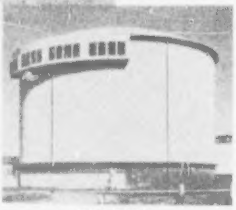
THTR

UNITED KINGDOM

- HARTLEPOOL - FIRST OF 625 MW(e) AGRs WITH MULTICAVITY PCRV
- DRAGON - FIRST HTGR, OPERATED FROM 1964-1975
- OVER 525 REACTOR YEARS OF OPERATING EXPERIENCE WITH GAS-COOLED REACTORS
- HEYSHAM - TWO UNIT 611 MW(e) AGR PLANT COMMITTED TO CONSTRUCTION IN 1981, FOR OPERATION IN 1987-1988



HARTLEPOOL



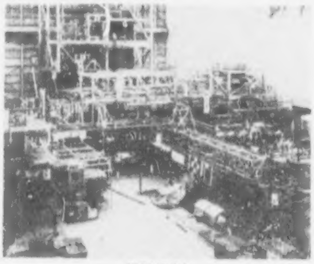
DRAGON

FRANCE

- OVER 95 REACTOR YEARS OF OPERATING EXPERIENCE
- CARMEN II FACILITY - CORE-FLOW AND HOT DUCT TESTS CONDUCTED - CAPABILITY FOR STEAM GENERATOR BOILING STABILITY TESTS

JAPAN

- VHTR — 50 MW(t) HTGR WITH 1000°C CORE OUTLET TEMPERATURE UNDER DEVELOPMENT CONSTRUCTION START TARGETED FOR 1986
- IN-PILE AND OUT-OF-PILE HIGH TEMPERATURE TEST LOOPS/HENDEL 10MW HELIUM LOOP FACILITY
- CURRENT FUNDING LEVEL $35 MILLION



HENDEL

TECHNICAL EXCHANGE AGREEMENTS

RELEVANT HTGR EXPERIENCE IS BROUGHT INTO THE U.S. PROGRAM THROUGH GOVERNMENT AND INDUSTRY EXCHANGE AGREEMENTS

EUROPE

- U.S. – GERMANY – SWITZERLAND – FRANCE "UMBRELLA AGREEMENT ON GAS COOLED REACTORS"
  GOVERNMENT LEVEL TECHNICAL COOPERATION AGREEMENT

GERMANY

- GA – HOCHTEMPERATUR REAKTORBAU (HRB)
  LICENSE AGREEMENT ON HTGR SYSTEMS AND COMPONENTS
- GA – HOCHTEMPERATUR BRENNELEMENT GMBH (HOBEG)
  LICENSE AGREEMENT ON HTGR FUEL
- DCRA – HOCHTEMPERATUR REAKTOR GESELLSCHAFT (HRG)
  MEMO OF COOPERATION ON HTGR WITH GERMAN UTILITY GROUP

SWITZERLAND

- GA – SULZER BROTHERS
  TECHNICAL EXCHANGE AGREEMENT ON HEAT EXCHANGERS

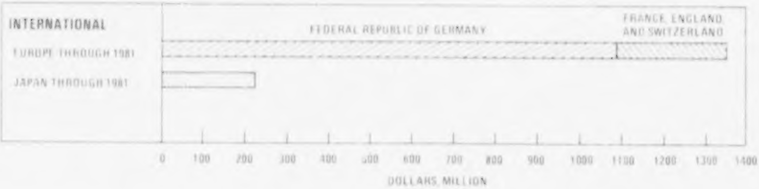
UK

- GA – CENTRAL ELECTRICITY GENERATING BOARD (CEGB)
  TECHNICAL EXCHANGE AGREEMENT ON GAS COOLED REACTORS
- GA – NATIONAL NUCLEAR CORP. (NNC)
  TECHNICAL EXCHANGE AGREEMENT ON GAS COOLED REACTORS

JAPAN

- GA – KAWASAKI HEAVY INDUSTRIES (KHI)
  LICENSE AGREEMENT ON HTGR SYSTEMS FOR JAPANESE VHTR PROGRAM
- GA – JAPAN ATOMIC ENERGY RESEARCH INSTITUTE (JAERI)
  TECHNICAL COOPERATION AGREEMENT ON HTGR
- GA – JAPAN ASSOCIATION FOR NUCLEAR PROCESS HEAT (JANP)
  TECHNICAL COOPERATION AGREEMENT ON HTGR APPLICATIONS

PROGRAM FUNDING THROUGH 1981



HTGR PROGRAM DESCRIPTION

THE CURRENT GOVERNMENT/INDUSTRYHTGR PROGRAM, WHICH IS FOCUSED ON THE DEVELOPMENT AND DEMONSTRATION OF A COMMERCIAL-SCALE HTGR STEAM CYCLE SYSTEM, HAS BROAD INDUSTRY, USER, AND NATIONAL LABORATORY INVOLVEMENT.

GENERAL ATOMIC, THE WORLD LEADER IN HTGR TECHNOLOGY, IS THE LEAD INDUSTRIAL FIRM INVOLVED IN THE PROGRAM. HOWEVER, OTHER EXPERIENCED INDUSTRIAL COMPANIES ARE ALSO DIRECTLY INVOLVED IN KEY AREAS.

- GENERAL ELECTRIC COMPANY
- COMBUSTION ENGINEERING COMPANY
- BECHTEL GROUP INC.
- UNITED ENGINEERS & CONSTRUCTORS

HTGR PROGRAM ACTIVITIES ARE ALSO CONDUCTED AT NATIONAL LABORATORIES.

- OAK RIDGE NATIONAL LABORATORY
- LOS ALAMOS NATIONAL LABORATORY

GAS-COOLED REACTOR ASSOCIATES (GCRA), REPRESENTS THE UTILITY/USER INTERESTS IN SUPPORT OF THE PROGRAM, AND PERFORMS AN OVERALL PROGRAM INTEGRATION ACTIVITY FOR THE GOVERNMENT.

LEAD PLANT PROGRAM

THE MAJOR FRACTION OF THE HTGR PROGRAM ACTIVITIES ARE DIRECTED TOWARD TECHNOLOGY DEVELOPMENT AND DESIGN SUPPORT ACTIVITIES TO ALLOW A COMMITMENT TO AN HTGR LEAD PLANT PROJECT

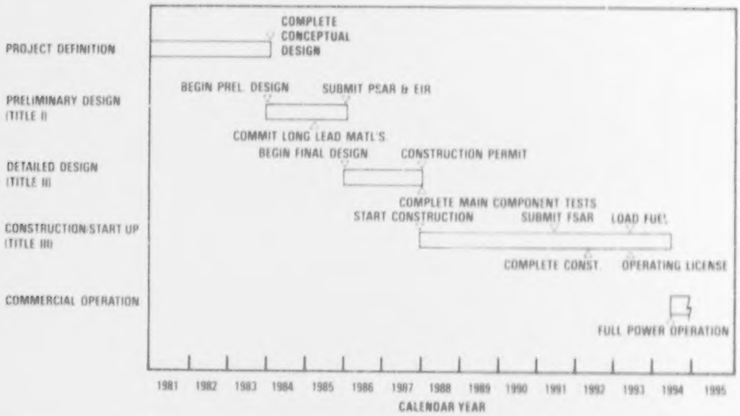
OBJECTIVES

THE MAJOR OBJECTIVES OF THE LEAD PLANT PROJECT INCLUDE

- DEMONSTRATION OF FULL COMMERCIAL SCALE HTGR SYSTEMS AND COMPONENTS INCLUDING FEATURES INCORPORATING TECHNOLOGY EVOLUTION AND FORT ST. VRAIN OPERATIONAL EXPERIENCE
- ESTABLISHING THE LICENSING CRITERIA FOR FOLLOW-ON COMMERCIAL HTGR SYSTEMS
- CONFIRMING INCENTIVES OF THE HTGR NUCLEAR SYSTEM FOR ELECTRIC PRODUCTION AND COGENERATION
- ESTABLISHING A BROAD INDUSTRIAL INFRASTRUCTURE TO SUPPORT A SUBSEQUENT COMMERCIAL HTGR INDUSTRY

SCHEDULE

THE LEAD PLANT PROGRAM IS DIRECTED TOWARD COMPLETION OF PROJECT DEFINITION PHASE ACTIVITIES IN FY 1983, FULL POWER OPERATION IN 1994



LEAD PLANT FUNDING APPROACH

A KEY PROJECT DEFINITION PHASE TASK IS TO DEVELOP MANAGEMENT, FUNDING, AND RISK SHARING ARRANGEMENTS

- INDUSTRY TO BEAR THE MAJOR PORTION OF THE LEAD PROJECT COSTS
- DIRECT GOVERNMENT PARTICIPATION LIMITED TO SUPPORT OF DESIGN AND DEVELOPMENT

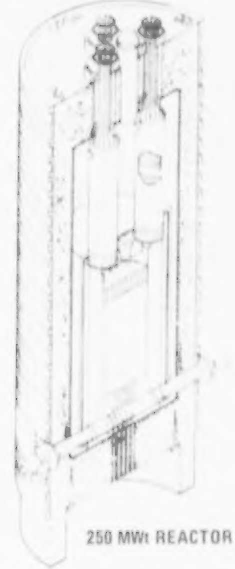
LEAD PLANT FUNDING (1981 $)

PHASE	GOV'T	INDUSTRY	TOTAL
PROJECT DEFINITION ('82-'83)	80	6	86
PRELIMINARY DESIGN ('84-'85)	148	23	171
DETAILED DESIGN ('86-'87)	176	71	247
CONSTRUCTION/STARTUP ('88-'94)	50	1360	1410
	$454	$1,460	$1,914
	(24%)	(76%)	

OTHER PROGRAM ACTIVITIES

IN ADDITION TO PRIMARY EFFORTS ON BASE TECHNOLOGY DEVELOPMENT AND THE STEAM ELECTRIC/COGENERATION LEAD PLANT PROJECT DESIGN AND APPLICATIONS, THE HTGR PROGRAM ALSO INCLUDES OTHER SECONDARY AND COMPLIMENTARY ACTIVITIES.

- CONCEPTUAL DESIGN OF HIGHER-TEMPERATURE VERSIONS OF THE HTGR, I.E., REFORMING PROCESS HEAT HTGR AND DIRECT CYCLE GAS TURBINE HTGR SYSTEMS.
- FEASIBILITY ASSESSMENT OF SMALL (APPROX. 250 MW(t)), MODULAR HTGR SYSTEMS FOR ELECTRIC/COGENERATION AND PROCESS HEAT APPLICATIONS.
- INVESTIGATION OF WASTE TREATMENT AND SPENT FUEL STORAGE FOR NEAR-TERM CLOSURE OF THE HTGR FUEL CYCLE, PLUS CONTINUED DEVELOPMENT OF TECHNOLOGY FOR EVENTUAL REPROCESSING OF HTGR-TYPE URANIUM/THORIUM FUEL ELEMENTS.
- DEVELOPMENT OF SAFETY/LICENSING CRITERIA SPECIFIC TO THE HTGR, AND REVIEW OF LONG-RANGE RESEARCH PLANS FOR VERIFICATION OF HTGR SAFETY.
- INTERNATIONAL COOPERATION



250 MWt REACTOR

THE SMALL STEAM-CYCLE/ COGENERATION HTGR SYSTEM CONSISTS OF A 250 MW(t) REACTOR CORE AND PRIMARY LOOPS HOUSED IN A PRESTRESSED CONCRETE REACTOR VESSEL. THE PRIMARY COOLANT LOOP CONTAINS ONCE-THROUGH STEAM GENERATORS, LOCATED IN THE UPPER PORTION OF THE PCRV, AND HORIZONTALLY MOUNTED HELIUM CIRCULATORS, DRIVEN BY SYNCHRONOUS ELECTRIC MOTORS. THIS EQUIPMENT IS ARRANGED IN THE VESSEL SO AS TO PROMOTE NATURAL CIRCULATION SHUTDOWN COOLING OF THE CORE. THE CONTROL RODS ENTER THE REACTOR CORE FROM THE VESSEL BOTTOM

UTILITY AND INDUSTRY SUPPORT

ELECTRIC UTILITY SUPPORT THRU GCRA

- IN 1978 A UTILITY ORGANIZATION, GAS-COOLED REACTOR ASSOCIATES (GCRA), WAS FORMED TO PROVIDE SUPPORT AND GUIDANCE TO PROGRAM. GCRA UTILITIES CURRENTLY REPRESENT OVER 25% OF INSTALLED ELECTRIC GENERATING CAPACITY IN UNITED STATES, OVER 25% OF ON-LINE NUCLEAR CAPACITY AND ABOUT 40% OF NUCLEAR CAPACITY NOW UNDER CONSTRUCTION.

ARIZONA PUBLIC SERVICE
CITY OF TACOMA
COLORADO UTE ELECTRIC ASSOCIATION
DELMARVA POWER & LIGHT
EMPIRE STATE ELEC. ENERGY RESEARCH CORP.
    CENTRAL HUDSON GAS & ELECTRIC
    CONSOLIDATED EDISON
    LONG ISLAND LIGHTING
    NEW YORK STATE ELECTRIC & GAS
    NIAGARA MOHAWK POWER
    ORANGE & ROCKLAND UTILITIES
    ROCHESTER GAS & ELECTRIC
FLORIDA POWER & LIGHT
GULF STATES UTILITIES
HELIUM BREEDER ASSOCIATES
IDAHO POWER
NORTHEAST UTILITIES
    CONNECTICUT LIGHT & POWER
    HARTFORD ELECTRIC LIGHT
    WESTERN MASSACHUSETTS ELECTRIC
    HOLYOKE WATER POWER
PACIFIC GAS & ELECTRIC
PACIFIC POWER & LIGHT
PHILADELPHIA ELECTRIC
PUBLIC SERVICE OF COLORADO
PUBLIC SERVICE OF NEW MEXICO
PUBLIC SERVICE ELECTRIC & GAS
PUGET SOUND POWER & LIGHT
SALT RIVER PROJECT
SAN DIEGO GAS & ELECTRIC
TENNESSEE VALLEY AUTHORITY

INDUSTRIAL USER SUPPORT

- IN 1979 A GROUP OF MAJOR INDUSTRIAL FIRMS FORMED A PROCESS HEAT USERS GROUP TO SUPPORT CONTINUED DEVELOPMENT OF HTGR. MOST OF THESE COMPANIES MERGED INTO PROCESS HEAT ADVISORY COMMITTEE ESTABLISHED BY GCRA IN 1981.

ALLIED CHEMICAL
CONSOLIDATED NATURAL GAS SERVICE
GULF OIL
INLAND STEEL
KAISER ALUMINUM & CHEMICAL
MOBIL RESEARCH & DEVELOPMENT
OWENS CORNING FIBERGLASS
SCALLOP COAL
UNITED GAS PIPE LINE

IN SEPTEMBER 1981 GCRA SPONSORED ITS THIRD ANNUAL HTGR CONFERENCE, WHICH WAS ATTENDED BY OVER 300 REPRESENTATIVES OF INDUSTRY, GOVERNMENT AND UTILITIES FROM EIGHT COUNTRIES.

FY 81 HTGR PROGRAM ACCOMPLISHMENTS

HTGR STEAM ELECTRIC/COGENERATION LEAD PROJECT ACTIVITIES

- ESTABLISHED REFERENCE DESIGN
- COMPLETED 20% OF NUCLEAR SYSTEM CONCEPTUAL DESIGN
- COMPLETED PRELIMINARY SITE-SPECIFIC STUDIES FOR FLORIDA POWER AND LIGHT, MID-ATLANTIC, AND INTER-MOUNTAIN CANDIDATE PROJECTS
- COMPLETED APPLICATION STUDIES – OIL SHALE, HEAVY OIL, CHEMICAL AND REFINING

BASE TECHNOLOGY DEVELOPMENT

- COMPLETED PRIORITIZED DESIGN DATA NEED PACKAGES
- SELECTED REFERENCE FUEL FOR LEU-TH FUEL CYCLE
- INITIATED CONSTRUCTION OF DEVELOPMENTAL COATER FOR LEU FUEL PARTICLES
- RECOMMENDED ENHANCED SAFETY FEATURES

ADVANCED SYSTEMS

- COMPLETED APPLICATION STUDIES – SYNTHETIC FUEL PRODUCTION

SPENT FUEL TREATMENT PROGRAM

- COMPLETED INSTALLATION OF OFF-GAS MONITORING SYSTEM

NRC SAFETY/LICENSING ACTIVITIES

REVIEWED LONG-RANGE RESEARCH PLAN FOR HTGR SAFETY CONFIRMATION

FY-81 NATIONAL PROGRAM FUNDING	
FOR HTGR APPLICATIONS AND BASE TECHNOLOGY	$40 MILLION
FOR SPENT FUEL TREATMENT PROGRAM	$ 3 MILLION
FOR NRC SAFETY/LICENSING ACTIVITIES	$ 4 MILLION

FY 82 HTGR PROGRAM

HTGR STEAM ELECTRIC/COGENERATION LEAD PROJECT ACTIVITIES

- COMPLETE 60% OF NUCLEAR STEAM CONCEPTUAL DESIGN
- COMPLETE PRELIMINARY SITE SPECIFIC STUDIES – GULF COAST REFINERY/CHEMICAL, ALUMINIUM PROCESSING AND REFINING CANDIDATE PROJECTS
- COMPLETE PROJECT DECISION PACKAGES
- COMPLETE PRELIMINARY MANAGEMENT PLAN

BASE TECHNOLOGY DEVELOPMENT

- COMPLETE REVIEW OF DESIGN AND DEVELOPMENT PROGRAMS
- INITIATE NON-DESTRUCTIVE EXAMINATION OF TEST FUEL ELEMENT FROM FSV
- PREPARE TEST FACILITY FOR MAIN CIRCULATOR BEARINGS AND SEALS TESTS
- INITIATE AIR FLOW TESTS OF UPPER AND LOWER CORE PLENUMS

ADVANCED SYSTEMS

- PERFORM PRE-CONCEPTUAL DESIGN AND FEASIBILITY STUDIES ON SMALL STEAM-CYCLE AND PROCESS HEAT HTGRS
- COMPLETE ECONOMIC EVALUATION OF LARGE HTGR PROCESS HEAT APPLICATIONS

SPENT FUEL TREATMENT PROGRAM

- COMPLETE TESTS ON HEAD END TREATMENT OF GERMAN PEBBLE BED FUEL

NRC SAFETY/LICENSING ACTIVITIES

- COMPLETE TOPICAL REPORTS ON HTGR SAFETY FOR NRC REVIEW

FY-82 NATIONAL PROGRAM FUNDING:

FOR HTGR APPLICATIONS AND BASE TECHNOLOGY	$35 MILLION
FOR SPENT FUEL TREATMENT PROGRAM	$ 3 MILLION
FOR NRC SAFETY/LICENSING ACTIVITIES	$ 4 MILLION

RECOMMENDED FY 83 HTGR PROGRAM

HTGR STEAM ELECTRIC/COGENERATION LEAD PROJECT ACTIVITIES

- COMPLETE CONCEPTUAL DESIGN, SCHEDULE AND COST ESTIMATES
- COMPLETE MANAGEMENT PLAN
- COMPLETE PRELIMINARY SITE REVIEW AND LICENSING DOCUMENT
- COMPLETE PRELIMINARY ENVIRONMENTAL IMPACT STATEMENT
- IDENTIFY LEAD PROJECT AND SITE
- LET MAJOR SUBCONTRACTS FOR DESIGN OF STEAM GENERATORS AND MOTORS/MOTOR CONTROLLERS FOR MAIN AND AUXILIARY CIRCULATORS

BASE TECHNOLOGY DEVELOPMENT

- PERFORM HOT-CELL DESTRUCTIVE EXAMINATION OF FSV TEST FUEL ELEMENT
- START MAIN CIRCULATOR BEARINGS AND SEALS TESTS
- INITIATE FULL-SCALE CORE AUXILIARY HEAT EXCHANGER TESTS
- SELECT CORE SUPPORT STRUCTURE GRAPHITE AND CONFIRM MATERIALS DATA

ADVANCED SYSTEMS

- COMPLETE PRECONCEPTUAL DESIGN OF SMALL REACTOR FOR COGENERATION AND PROCESS HEAT APPLICATIONS
- COMPARE DESIGN, ECONOMICS, AVAILABILITY AND LICENSABILITY OF MONOLITHIC AND MODULAR PLANTS

SPENT FUEL TREATMENT PROGRAM

- COMPLETE FLUID-BED BURNER OFF-GAS TREATMENT TEST PROGRAM
- CONTINUE LEAD PLANT SPENT FUEL TRANSPORTATION/STORAGE/PROCESSING STUDIES

NRC SAFETY/LICENSING ACTIVITIES

- INTERACT WITH NRC ON SPECIFIC SITE REVIEW AND GENERIC LICENSING ISSUES

RECOMMENDED FY-83 NATIONAL PROGRAM FUNDING:

FOR HTGR PROJECT AND BASE TECHNOLOGY		$45 MILLION
– BASE TECHNOLOGY DEVELOPMENT	$24 MILLION	
– LEAD PLANT DESIGN AND APPLICATION STUDIES	$16 MILLION	
– ADVANCED SYSTEMS	$ 5 MILLION	
FOR SPENT FUEL TREATMENT PROGRAM		$ 3 MILLION
FOR NRC SAFETY/LICENSING ACTIVITIES		$ 4 MILLION

STATEMENT OF TOM JOHNSTON, VICE PRESIDENT, GENERAL ATOMIC CO.

Mr. JOHNSTON. Thank you, Mr. Chairman. I am Tom Johnston, vice president of General Atomic. I appreciate the opportunity to appear before this subcommittee today on behalf of the HTGR program. The HTGR has been recognized by the DOE, industry, the Congress, and the subcommittee in particular as an advanced high efficiency reactor system which can provide benefits, not only to the ultimate owner-operators, but to public service companies, and also in the national interest as well.

Specifically, the HTGR can provide higher thermal efficiencies and improvements in the utilization of the natural resources that we have in this country. The HTGR also provides the highest level of safety, safety which is based principally on the inherent features of the system rather than the engineered system.

Further, the operation of the HTGR system, as was mentioned by Mr. Walker, demonstrated substantially reduced levels of gaseous waste, liquid waste, and solid waste, while it reduced exposures of radiation to the operating personnel. These features are of interest not only to the owner-operators of nuclear plants but we believe important in regaining public acceptance of nuclear power in this country.

During the past several years, another aspect of the HTGR has come to be recognized and that is that this technology cannot only be applied to the conventional nuclear role in electric generation, but can also fulfill the unique role in the second important energy area; namely, providing high temperature steam and heat to meet the industrial sector's requirements for clean, inexpensive energy.

In 1980, over 26 percent of the total U.S. gross energy consumption was in the industrial sector, with the overwhelming majority of this energy being provided by either natural gas or oil. Studies have shown that over 77 percent of this industrial energy requirement is required at temperatures of 1,000°F or less.

The HTGR along with nuclear options has the capability to serve most of this market, although coal must and certainly will displace both oil and gas in many of these industrial applications in the future. The HTGR can and should also play a major role. It cannot only do the job efficiently and economically, but it has the subsidiary advantage of substantially reduced emissions from SO_X, NO_X, CO_2 and of cutting down on particular emissions from such power supply. So it is the recognition of these factors that led to the support of this program from the major segment of the electric utility industry acting through Gas-Cooled Reactor Associates, as well as for major companies representing oil, chemical gas and other process industries. These groups along with General Atomic since 1957 have provided the larger share of support for the technology representing over $1 billion to date.

The potential benefits of the HTGR have also been recognized other places in the world, in particular West Germany and Japan, and both of these countries are proceeding with well-established national programs.

A summary of the progress has been made on the DOE-HTGR program during fiscal year 1981 and 1982 as contained in the formal document that have been submitted as a part of the testimony. It includes not only a review of technology and design activities, but also of the specific undertakings which would lead to an HTGR lead plant project.

Also contained in that formal document is an outline of the fiscal year 1983 program, which is being proposed. Specifically for fiscal year 1983, General Atomic and the other program participants are requesting this committee provide budget authority of some $45 million for continuation of the HTGR lead plant project and base technology activities, along with $3 million for the HTGR fuel treatment program.

That concludes my statement. And I thank you again for the opportunity to appear.

Mr. Carey. Dr. Gilleland will go ahead with the fusion portion of the presentation.

STATEMENT OF DR. JOHN R. GILLELAND, DIVISION DIRECTOR, GENERAL ATOMIC CO.

Dr. Gilleland. Thank you, Mr. Chairman. I am going to spend a few minutes talking about our fusion program. General Atomic's fusion program is the first to be conducted by private industry. As a matter of fact, it began back in 1957 when there were not many people doing fusion research.

The present program has as its centerpiece Doublet III, which I guess is the largest operating tokamak in the world. We are very proud of that effort. The machine has as its goal the making of a plasma like the one need for a fusion reactor. We are proud of our progress. We started operations with the machine in 1978.

The machine was put together a few days ahead of schedule. The schedule had been set some 4 years prior to that. I also promised some hard-working people in San Diego I would mention that we made all eight of our program milestones this year, DOE milestones, on or ahead of schedule and on or under cost. And since good news is hard to come by these days, I thought I would mention that.

The Japanese Atomic Energy Research Institute joined the Department of Energy in conducting research on Doublet III a couple of years ago. We feel this is strong international endorsement of DOE's program of research. It is the largest such joint research effort going these days.

Doublet III is capable of accommodating large, highly shaped plasmas of the size of those planned for TFTR and JT-60. The machine is unique because the machine is not only highly sophisticated but it is very flexible and we have taken this flexibility into account in our experimental program. The program has had three phases. The first two have already affected reactor designs around the world.

The preparations for the third phase are underway. We are planning to change the vacuum vessel in Doublet III in the third stage operation in Doublet III. We replace the present vessel with a big D-shaped vessel, which will give us a very large plasma which approximates the most essential features that people are planning to use in the first engineering reactor. So we feel that this activity, which is in your fiscal year 1983 budget, will be very cost effective, will allow you to do some fusion engineering tests without acquiring a new operating mortgage.

Now, I would like to make a few comments on the fusion budget as a whole. I have been told, and I guess I heard it here earlier today, that some people say fusion is 50 or 70 years away and I think that is unwarranted pessimism. I believe that the results, which have been coming out of the machine lately, have been highly favorable, that the full promise of fusion is still alive and well.

I fully support the provisions that are in the Fusion Engineering Act of 1980. I think that when the economy improves, at least, or perhaps sooner, we should proceed vigorously with the provisions of that act. The budget as it stands, the President's budget, I think, is a reasonably well-balanced budget. Of course, we all wish it were larger.

I believe that is all I have to say, Mr. Chairman. Thank you very much.

Mr. CAREY. That will conclude our remarks, Mr. Chairman.

Senator DOMENICI. Thank you very much. I think we will hold our questions, if that is all right. We have two more witnesses. Dr. Glass, president and chief operating officer, KMS Fusion, Inc.

STATEMENT OF DR. ALEXANDER J. GLASS, PRESIDENT, KMS FUSION, INC.

Dr. GLASS. Thank you, sir. I am Alexander Glass and I am president of KMS Fusion and I am very grateful for the opportunity to appear here before your committee today. I have submitted a written statement, which I request would be included in the record.

KMS Fusion is a private company located in Ann Arbor, Mich., which has been conducting research on inertial fusion for over a decade and has been receiving support from the agencies of the U.S. Government since 1975 for this program of research.

Inertial fusion is one of two technical approaches to control fusion energy. You have heard this morning a very eloquent statement from Mr. McCormack on the magnetic fusion program and I would just like to in passing add my endorsement to those remarks.

In inertial fusion energy from a powerful laser or particle beam is concentrated on a tiny container of hydrogen fuel, heating it and compressing it until the fusion reaction occurs, releasing more energy than was invested to heat the fuel in the first place.

This is the process, of course, of the hydrogen bomb carried out in miniature. Inertial fusion is seen as an alternative to magnetic fusion, based on somewhat different physical principles and therefore seen as an alternative long-term energy supply and in the near-term has benefits for nuclear weapons design.

Accordingly, it has been supported for several years through the defense programs portion of the Department of Energy's budget. Speaking of long-term participant in this program, I want to say we are grateful for the continuing support, not only of the defense program area in the Department of Energy, but of the various committees of Congress, including this one.

The immediate objective in the inertial fusion program is achieving ignition and ignition here refers to the point at which a significant amount of heating of the fuel is carried out by the energy released from the fusion process. There are two major facilities under construction in this country today, which will bring us close to the threshold of ignition. One, the Nova laser has a large Lawrence Livermore laboratory which is scheduled to be operational between 1984 and 1985 and the other the particle beam fusion accelerator at the Sandia Laboratory in Albuquerque, which should be operational in roughly this same time frame.

These two facilities have the capability of providing us with the critical information we need to continue our evaluation of the promise of inertial fusion. There is no doubt that a thermal nuclear reaction can be ignited and a gain can be achieved in inertial fusion at some cost and at some scale. The question is at what cost and at what scale.

And that statement is based on weapon design experience. The requirements for fusion are extremely stringent. For inertial fusion you need to heat the fuel to six times the temperature of the solar interior and you have to compress it to a density of ten times that of solid lead and those seem very formidable, but the achievement of the necessary temperature has been demonstrated several times over and in experiments carried out of the Lawrence Livermore Laboratory 2 years ago, one-tenth of the required density was achieved.

So the question is primarily one of what is the cost of fusion driver. KMS Fusion plays a unique role in the program. It is one of the six laboratories supported on a continuing basis. And of those six, it is the only private participant. Last year we received about $9.3 million in operating funds, which comprised a little less than 8 percent of the total funds in the program.

We operate a flexible experimental facility, on which we carried out 440 experiments last year. And in addition, we provide target fabrication support for our own work and for most of the other laboratories in the program.

During the last year, we carried out three separate experimental compaigns. I will not go into the details here in the interest of time. I have spelled out some of our achievements in the testimony. The main thing I want to point out is we carry out both classified and unclassified experiments. As you are undoubtedly aware, some of the concepts associated with this approach to fusion are classified.

One of the main roles of KMS Fusion is to keep a steady stream of unclassified results coming out of the program. I feel personally that that is very vital a requirement that we keep the scientific community at large involved in the progress of this program.

We have benefited greatly from the collaboration with other laboratories in the program, especially the Lawrence Livermore Laboratory and the Naval Research Laboratory, here in Washington.

In 1981, the operating funds for the national inertial fusion program were approximately $140 million. In 1982, the budget level for operating funds was $125 million, which, allowing for inflation, represented 20 percent reduction in our operating funds. The 1983 proposal of the administration, as recently amended, is approximately $122 million for operating and that, even so, is another 10 percent cut over the 1982 figure.

The impact of this continued reduction in funding, as taken in 1982, was to reduce the scope of the research and to slow the pace of the program. The only thing that is being funded at any significant level in the inertial fusion program today is the main line investigation supporting the ignition milestone.

The university involvement and supporting technology developments has been all but eliminated from the program because of the funding reductions. I have great concern, which I think is shared by all my colleagues in this program, that further reductions of the sort that are envisioned in the 1983 administration proposal will cripple the program.

We are not pursuing many of the major problems of interest. That is, as I mentioned before, the primary question here is, what cost is associated with the achievement of ignition by inertial fusion and that cost is associated with the cost of the driver, the particle beam or the laser. And very little effort is going on now in addressing those issues, technology cost issues.

We are not looking with very much effort at the energy applications of fusion. In fact, we are not looking very extensively at either energy or military applications in this program.

I realize that budget constraints exist, but I am very concerned about the net result of further reductions in our budget. I view these as counterproductive and I feel the full impact will not be felt for a couple of years until these major facilities that are in the course of construction today come on line, because associated with these facilities unavoidably will be higher operating costs.

I feel the scientific progress in the program has been good, that the new facilities coming on line will bring us even closer to the demonstration of ignition and the definition of the requirements for an inertial fusion, reactor. I feel that we need to start design studies for the next generation of facilities without delay.

KMS Fusion, with its 15,000 shareholders, retains its faith and strong dedication to fusion energy and particularly to the pursuit of inertial fusion as an energy source in the long term. And we see near term benefits, not only to the weapons design activity, but to other technologies as well.

I hope that the program will continue to receive adequate support, and I thank you very much for the opportunity to be here today.

[The prepared statement of Dr. Glass follows:]

INERTIAL CONFINEMENT FUSION RESEARCH AT KMS Fusion, Inc.

Dr. Alexander J. Glass, President

KMS Fusion, Inc. is a private company located in Ann Arbor, Michigan which conducts research in Inertial Confinement Fusion (ICF), under the sponsorship of the U.S. Department of Energy. Fusion, which is the process which provides the sun's heat, and the awesome power of the hydrogen bomb, is under development by the DOE as a future source of energy. Inertial Confinement Fusion, which is based on the same physical principles as the hydrogen bomb, also provides information beneficial to the design of thermonuclear weapons, and is thus supported as part of the Defense Programs budget within DOE. In the 1983 budget presented by the administration, these activities are subsumed under the Energy Research and Technology Administration of the Department of Commerce.

In order for either the defense or energy applications of fusion to be practical, it must be demonstrated that the fusion fuel, a mixture of the isotopic forms of hydrogen, deuterium and tritium, can be heated and compressed to the point where significant energy is released from the fusion process. This milestone is identified as the ignition of the thermonuclear reaction. At present, the primary objective of the ICF program is the demonstration of ignition. Facilities currently under construction at the Lawrence Livermore National Laboratory (LLNL) and the Sandia Laboratory in Albuquerque (SLA), should approach ignition conditions within the next five years. KMS Fusion carried out research in laser-driven fusion, one approach to ICF, in support of the achievement of the ignition milestone.

KMS Fusion is a pioneer in ICF research. The company was founded in 1971, and operated with private funding until 1975, when it received its first support from the Energy Research and Development Administration (ERDA). Since 1975, the company has received funding from ERDA and the Department of Energy (DOE). In January, 1982, KMS Fusion was awarded a new five-year contract to continue its program of ICF research under DOE sponsorship.

In 1979, the Assistant Secretary of Energy for Defense Programs instituted Lead Laboratory management in the ICF program. The Lawrence Livermore National Laboratory (LLNL) was designated as Lead Laboratory for 1.06 micrometer and shorter-wavelength experiments, referred to as Glass Laser Experiments. As one of four U.S. laboratories conducting ICF experiments with a powerful glass laser, KMS Fusion was designated a "support laboratory" in the Glass Laser Experiments program. Under Lead Laboratory management, the company's research activities are fully integrated into the national ICF program. Cooperation with other laboratories, especially LLNL, is fostered under this arrangement. In the last year, experiments were carried out at KMS Fusion by scientists from both LLNL and the Naval Research Laboratory in Washington, D.C. working jointly with our staff.

KMS Fusion has contributed major achievements to the ICF program since its inception. The first thermonuclear neutrons obtained from a laser-driven implosion were observed at KMS Fusion in May, 1974. The company pioneered the use of visible light for ICF experiments, an approach subsequently adopted by several other laboratories. During the past year, KMS Fusion has carried out experiments using cryogenically frozen fuel, a technique which promises to yield improved target performance. We are the only laboratory in the U.S. to use cryogenically cooled targets in ICF experiments, to date.

At present, KMS Fusion is one of six major participants in the ICF program. The company received $9.3 million in operating funds this year, only about 7.6 percent of the national program total. Our activities are aimed at providing increased understanding of the critical aspects of fusion target performance, and the requirements of fusion target fabrication. We operate a flexible experimental facility, centered around a powerful laser, Chroma I, which is capable of producing two trillion watts of infrared light. The laser output can be efficiently converted to either visible or ultraviolet frequencies. During the past year, KMS Fusion has conducted three very productive experimental sequences, using this laser. 440 target experiments were carried out, 276 with infrared light and 164 with visible light. In the first experimental series, a jet of high-pressure gas was ionized with the laser beam. This experiment was designed to simulate the conditions that will be experienced in very large targets, such as will be needed for fusion reactors. The gas jet allows experimenters to isolate the various physics phenomena which occur in large targets, and to study them in a carefully controlled environment. The results of these experiments were of great interest to the scientific community, and further investigations based on the KMS Fusion experiments, are planned by both the Naval Research Laboratory, in Washington, D.C., and the Los Alamos Scientific Laboratory in New Mexico.

The second campaign conducted by the company involved a study of processes which occur in radiation-driven targets. One approach to laser-driven ICF is based on converting laser light to x-rays inside a closed container, or "hohlraum". Details of these experiments are classified. However, we can report that, using diagnostic techniques developed at KMS Fusion, we were able to observe processes within these targets which had not been previously investigated. Research on these radiation-driven targets will continue in 1982.

Starting late in 1981, we have been investigating the implosion of cryogenic targets, and their sensitivity to the wavelength (color) of the laser light, the shape of the laser pulse in time, and the design of the targets. For the first time, we have observed improved performance of cryogenic targets over room-temperature targets. Cryogenic targets are proposed for every high-yield application of laser fusion, yet KMS Fusion is the only laboratory to investigate their behavior experimentally. We have obtained good agreement between our experimental results and our computer modeling of these experiments, which were carried out using infrared light, and project greatly improved performance with visible light. The visible-light series of experiments is currently underway, and represents the first time that any laboratory has combined the features of cryogenic fuel, visible light, and pulse shaping in a single experimental series.

Approximately half of the resources of KMS Fusion are devoted to materials science developments, leading to improved targets and fuel containers for fusion experiments. Much of this effort has been devoted to the production of glass shells used as fuel containers. The company supplies targets not only for its own experiments, but also supplies targets and target components to other program participants. In 1982, we have placed two KMS Fusion scientists at LLNL, to facilitate transfer of glass droplet technology to KMS Fusion, so that we can take on the bulk of glass shell production for the LLNL program.

During the past year, there has been continuing progress throughout the ICF program in understanding the deposition of laser energy in fusion targets, and the transport of the deposited energy into the target interior. With the larger facilities currently under construction, it will be possible to investigate the dynamics of target implosion, and the compression and heating of the fusion fuel. These experiments will define the target and driver parameters required for the achievement of ignition.

We know that to achieve ignition requires that the fusion fuel be heated to a temperature six times that of the solar interior, and compressed to a density ten times that of solid lead. We also know that we can achieve these conditions. Nuclear weapons design experience provides substantial guidance for ICF target design. Additionally, fusion fuel has been heated to ignition temperatures, albeit at low density, in several laboratories, and compressed to one-tenth the required density, albeit at low temperature, in experiments carried out at LLNL in 1979. Thus, the immediate objective is to determine how to achieve ignition, and beyond that, significant net energy yield, at the lowest possible cost.

This objective requires both scientific and engineering investigations; scientific studies to provide the understanding of how to optimize target performance, and engineering studies to reduce the cost of the required driver, whether laser or particle-beam. This is the case for either defense or energy applications. In either case, the cost of a facility capable of producing a significant fusion yield is prohibitive, based on current technology.

Because of budget limitations, the ICF program is currently only pursuing the scientific investigations. Furthermore, recent budget reductions have even reduced the scope of the scientific research within the programs, and significantly slowed the pace of progress. A major reduction in funding occurred in 1982. The 1981 operating budget for ICF was $140 million. In 1982, the House Appropriations Committee recommendation of $140 million was reduced in conference to $122 million, which represented a 20 percent reduction from the 1981 level, allowing for inflation. The Administration request for 1983 calls for a further decrease of program funding to an operating level of $105 million, corresponding to an additional reduction of 25 percent, when inflation is taken into account. Additionally, in the 1983 Administration request, the funding to complete the Nova project is reduced to zero.

Last year's budget actions have already produced a profound impact on the ICF program. In January of this year, KMS Fusion underwent a staff reduction of 15 percent, and deferred all but the most essential expenditures. The other major participants in the program reduced their efforts similarly. Further reduction to the level of the Administration request would have a crippling effect on the program, and would represent a false economy. The ICF program represents a cumulative investment of over $1 billion. The new facilities coming on line at LLNL, SLA, and Los Alamos in the next few years will provide valuable new data, but will require expanded support, both within the weapons laboratories and among the support laboratories, if their use is to be cost-effective.

All of the participants in the ICF program recognize the necessity to operate within a realistic budget. However, we are close to the level at which the best interests of the nation are not served. The long-term consequences of reducing the level of activity, slowing the pace of progress, and deferring the essential development of lower-cost technology begin to outweigh the short-term savings further budget cuts might realize.

KMS Fusion remains an enthusiastic participant in the national ICF program, and strongly urges the continuation of the program at an adequate level of funding. We feel that scientific progress is continuing, although at a reduced pace imposed by budget constraints. We feel that the major facilities currently under construction will bring the ignition milestone within our grasp, and provide a clearer definition of the requirements for a high yield facility for either energy or defense applications. We are concerned that further reductions in funding will have a negative impact on the productivity of the program, especially in years to come, and will preclude the necessary development of the low-cost driver technology the program will ultimately require.

KMS Fusion sees this program as a promising long-term solution to the world's energy supply problems, with significant near-term benefits for both defense and civilian technology. We hope that adequate funding will be provided to maintain the ICF program's progress toward these worthwhile objectives.

Senator DOMENICI. I thank you very much, Dr. Glass.

Next is Warren P. Chernock, vice president of development, nuclear power systems, Combustion Engineering, Inc.

STATEMENT OF WARREN P. CHERNOCK, VICE PRESIDENT OF DEVELOPMENT, NUCLEAR POWER SYSTEMS, COMBUSTION ENGINEERING, INC.

Mr. CHERNOCK. Mr. Chairman, I have prepared written testimony and I request it be made part of the record.

Senator DOMENICI. It will be made part of the record. If I did not so indicate, all other witnesses' written testimony will be made part of the record also.

Mr. CHERNOCK. With your tasks today, you hardly need an individual like me down here indicating that there need to be budget additions made, but in looking at your prioritization of programs, it might be worthwhile to ask yourself a question: How many programs do you have that have a cost benefit ratio of 1 to about 400?

I would like to highlight a part of the light water reactor DOE budget that has that kind of a cost ratio potential. And I would like to focus my oral testimony on that one program, which is the high burnup fuel program.

The question that might be asked is why proceed with high burnup fuel. There are two distinct advantages associated with new fuel technology. One is associated with an 18-month cycle. In order to pursue an 18-month cycle, you don't need high burnup fuel.

With an 18-month cycle, you improve reactor availability. Reactors are normally shut down once a year for refueling. With an 18-month cycle, they are shut down once every year and a half. However, with an 18-month cycle without high burnup fuel, you need about 16 percent more enrichment, which now burdens the enrichment facilities.

You need 11 percent more fuel and you will increase as I stated reactor availability. I now look at the present 12-month cycle, and I increase burnup only. This means then that we are providing fuel with a burnup capability of about 4 to 5 years versus today's capability of about 3 years.

In this particular case, you can reduce uranium requirements by about 15 percent. Now, let us look at the real payoff. If I take an 18-month cycle and I increase the burnup, I reduce the uranium requirements by about 3 percent and most significantly I reduce the number of fuel assemblies that need to be fabricated and disposed of each year by 40 percent.

This also relieves the constipation at the tailend of the fuel cycle. Now, there are a number of waste management bills being reviewed at the present time by the Congress. In looking at a pursuit in completion of this high burnup program, you are then looking at a requirement for 60 percent of the total fuel to be stored. In other words, that is a reduction of 40 percent in the amount of fuel that must be stored.

I started off my discussion by indicating that this was a highly cost effective program. Testimony or a letter actually from Shelby Brewer, assistant secretary for Nuclear Energy, and Mr. Otenger on the Energy, Conservation and Power Committee on October 27, 1981, as well as an analysis by the U.S. General Accounting Office on November 18, 1981, arrived at the fact that pursuit of this high burnup fuel program will result in a net savings to the rate paying public of at least $13 billion, that was billion not million, by the year 2000.

I have done a rough back of the envelope calculation, and it is rough, I am presuming something on the order of 6 weeks per year for a refueling shutdown times 3 years, which is 8 weeks every 2 or 3 years. So on a 12-month cycle, we are looking at something on the order of 6 weeks a year.

With an 18-month cycle we end up with 12 weeks every 3 years, which means we save 6 weeks every 3 years, which means we save 42 days every 3 years, which converts to something on the order of about $14 million per year savings. If we look at just 70 reactors, roughly the 70 reactors we now have operating, this is on the order of $1 billion a year and integrated through the year 2000 without any other reactors coming on line, which, of course, is not the fact, I get a number of about $18 billion. So the GAO number of $13 billion appears to me to be realistic.

Now, the current proposal is that these high fuel burnup programs, this is OMB's version of it, continue with a one-vendor concept. The problem with a one-vendor concept is it provides a competitive advantage to that vendor that is selected.

Second, at least as far as our participation in the program DOE was a very hard negotiator. We provided head-end technology. We value that head-on technology, which is now a matter of public record on the order of millions of dollars.

We would view a cancellation of that program as a breach of good faith. There in another item that I think might be important in viewing this one vendor concept. There was a fact finding team report prepared by DOE in response to the Nuclear Safety Act of 1980. I have the exact public law number, just to make that a matter of record. It is Public Law 96-567.

I will quote from page 9 of that report:

> Another important facet of this joint Department of Energy/Nuclear Steam Supply System Vendor/Utilities Programs is they preclude any one organization

from developing a monopolistic position in the market place, a concern expressed by the utilities, with regard to reload course.

So I again emphasize the importance of continuing this program with all of the vendors involved in the work now underway. We have also lost our world leadership in nuclear technology. This is one area where we are clearly ahead of the rest of the world with respect to nuclear technology.

Our high burnup programs are clearly leading the rest of the world. Now, I would like to point out that that leadership is being challenged by both the French and the Germans and if we do not continue these programs at the level indicated by the current programmatic efforts, I think we will lose that lead.

So what I would like to do is I would like to make a few closing comments. One, I do concur with the Nuclear Safety Oversight Committee conclusion report of September 1981, which confirms that many of the priorities of the DOE fact-finding team report, mentioned earlier, with respect to pursuing these high burnup programs to completion, I believe that they need to be completed on the basis of the extremely high—I am sorry, extremely low cost benefit relationship, which is about 1 to 400 and I would also like to plea that we don't debate this issue every year, that we decide here and now that these programs are in the best interest of the U.S. ratepayer, the U.S. Government and that these programs be pursued to completion.

On the contrary, I might also recommend that there be consideration given to the potential for increasing the funding level for these programs in future years to meet the competitive aspects of both French and German technology, some of which are, at least on paper, aiming at burnup substantially higher than our programs are aimed at today.

And one last comment, and that is that in the Nuclear Safety Oversight Committee conclusions, a statement was made confirming the need for a very strong DOE staff with LWR experience. In my written testimony, I have pleaded for the institution at the highest level possible within DOE of individuals with LWR experience. I think that this is extremely important to carry these programs forward.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Chernock follows:]

TESTIMONY TO THE SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT OF THE UNITED STATES SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

by Warren P. Chernock
Combustion Engineering, Inc.
on April 26, 1982

My name is Warren Chernock. I am Vice President of Development, Nuclear Power Systems, Combustion Engineering, Inc. I am here today to comment on the Department of Energy budget request for Light Water Reactor Systems Research and Development Programs for Fiscal Year 1983.

One of the stated overall objectives of the Light Water Reactor (LWR) Systems Program is "to support the revitalization of the nuclear option and to contribute to the resolution of nuclear industry institutional problems." The proposed level of funding for the Fiscal Year 1983 LWR programs does not appear to be consistent with the stated objective. I urge you to reconsider the funding levels for LWR programs in FY 1983 with the aim of increasing the budget authorization to permit, as a bare minimum, the continuation of programs already underway and to consider increased funding for those programs which are at a marginal funding level at this time.

I fully recognize the pressure on the Congress for budget reductions in FY 1983. However, revitalization of the LWR to retain the nuclear option is an objective of this Administration and it is within this framework that I am providing my comments on the FY 1983 budget and programs.

It is our belief that the ability to maintain the nuclear option in the United States is strongly dependent upon the resurgence of a healthy LWR industry. Many of the problems facing the industry at this time, such as: long lead times, waste disposal and regulatory uncertainty, are institutional in nature. DOE should address these institutional problems. Failure to maintain a market for light water reactors will have a negative impact on the nuclear option in this country.

COMMENTS ON DOE LIGHT WATER REACTOR SYSTEMS PROGRAMS

A. LWR Safety Technology

This subprogram identifies activities to be emphasized in the DOE program plan.

(1) 10CFR 50 Appendix K

While we strongly agree on the need to take actions to ameliorate regulatory impacts, we do not believe that efforts to relieve requirements of 10CFR 50 Appendix K should be of high priority at this time. Current and near-future fuel designs are known to be capable of accommodating the ECCS (Emergency Core Cooling System) restrictions contained in Appendix K. Furthermore, changes in Appendix K would require a new Rule-making Hearing and would involve substantial expenditure of man-power and funds on the part of the NRC, fuel vendors and the utility industry with no benefit in terms of improved safety. In addition, with reductions in NRC budgets contemplated for FY 1983, the diversion of manpower to such a marginal activity could result in licensing delays for plants which are, or are about to become, docketed for review. Other NSSS and fuel vendors, as well as representatives of the utility industry should be contacted to determine their comments and recommendations concerning changes in Appendix K before any funds are expended for such activities.

On the other hand, the concept of utilizing Government created data to justify a relaxation in licensing conservatism is meritorious and the following three step process should be considered:

1. Identify areas in which licensing conservatisms could be reduced and for which licensing relaxation has a reasonable chance of being achieved, without adversely impacting the health and safety of the public, and which could provide tangible benefits to the ratepayer.

2. Examine, in detail, completed U.S. Government programs, available results from other countries and published literature to identify programs containing appropriate data, which, if properly analyzed, would provide a basis for licensing relaxation.
3. Apply the data to remove conservatism.

It is our opinion that the following areas, among others, would prove to be fruitful for removing conservatisms:

a. Seismic design bases (reduction of the level and/or breadth of the peak response of Regulatory Guide 1.60).
b. Seismic design practice (obtain credit for energy absorption from the plasticity of piping runs).
c. Pipe break criteria (aimed at relaxing the current double ended pipe break assumptions which influence the design of support structures and pipe whip restraints).
d. Fission product release assumptions and transport assumptions (some analyses indicate that the source term assumptions are high by two to three orders of magnitude).

(2) Nuclear Safety Research, Development and Demonstration Act of 1980 (Public Law #96-567)

DOE was required to submit a report to Congress concerning recommendations for implementation of this Public Law. At the request of DOE, we have reviewed this Report and we have supplied written comments to DOE. Some of these comments are summarized below:

1. C-E supports the DOE conclusion that a National Reactor Engineering Simulator Facility (Section 5 of the Act) and a Federal Nuclear Operations Corps (Section 6 of the Act) are neither necessary nor appropriate and we endorse the DOE recommendation against pursuit of their further consideration.
2. It is intended that results of safety related programs be used to enhance the effectiveness and speed of licensing processes. Specific DOE and NRC roles should be clearly defined and, if safety related programs are initiated, advance concurrence on their relevance should be obtained from NRC and specific implications should be identified for each of the possible potential result paths.
3. It is our belief that resolution of the major problem of long lead times can best be accomplished by:

    a. Identifying, in a limited time, the major factors which have caused an increase in construction time from 5 years (Maine Yankee) to the current period of 10 to 12 years, or more.
    b. Determining, in a realistic manner, the improvements which can now be made on the basis of a more mature industry with many reactor years of

opertion, and which can provide both reduced lead times and less plant complexity without compromising safety to the public. A target lead time of 6 to 7 years is possible. Identifying these improvements should be performed with expediency so that they may be implemented with little delay.

4. The Report which we reviewed does not provide sufficient detail in Section 8 (Program Management Plan for the Conduct of A Research, Development and Demonstration Program for Improving the Safety of Nuclear Powerplants) on what will be done, who will do it, who will manage the programs and how the programs will be performed. In addition, schedules and funding requirements were not included. This Report does, however, indicate that program planning will be performed in coordination with industry and NRC. Possibly this will provide the DOE/NRC link needed to lend viable acceptance by NRC of programmatic results. On the other hand, we, and other members of industry, have already provided extensive input to the DOE Fact Finding Team Report issued in July, 1981 which summarized, on a consensus basis, industry comments on light water reactor safety research. We, therefore, do not understand the basis for postponing much of the detailed planning. We do note that Working Groups have been established and that reports containing Working Groups recommendations are scheduled

to be provided to DOE by April 30, 1982. These recommendations would then form the bases of DOE programmatic responses to Section 8 of Public Law #96-567. We hope to have an opportunity to review and comment on the details of the proposed DOE program before it is implemented.

On the other hand, our views concerning "Overall Program Management" might be helpful in formulating future DOE plans for implementation of this Public Law. It is our recommendation that Overall Program Management be provided at the highest possible level within DOE. We propose that consideration be given to establishing an Advisory Committee, including industry representatives, for this program. The function of this committee would be to act in an advisory capacity to DOE and this committee should be empowered to recommend, where necessary, changes, deletions or additions to the program to assure its continuing focus on the major objectives of the Law itself. (The term "industry" should be considered to include, as appropriate, Institute for Nuclear Power Operations (INPO), Atomic Industrial Forum (AIF), Industry Degraded Core Rulemaking Program (IDCOR), Electric Power Research Institute (EPRI) and individual reactor vendors and utilities).

The appropriateness of the requested funding should be weighed against the approximately $200M NRC budget for safety research and development to determine how a viable portion of the NRC budget can be redirected away from the narrow goals of NRC R&D, which tend to be "confirmatory" in nature, and directed toward reducing lead times and regulatory uncertainty as well as reducing licensing conservatisms without adversely impacting the health and safety of the public. It is my opinion that funds well in excess of $1M for FY 1983 will be required for DOE to engage in a meaningful relationship with NRC to meet the objectives of the Act. Persuasion and not duplication should be the key element of such a process. However, a Program Plan and strategy must be established by DOE and accepted by NRC if such a program is to succeed.

(3) The Conduct of Selected R and D Efforts to Provide a Basis for Better Compatibility Between Regulatory and Plant Operations Requirements

Doe has conducted selected R&D efforts to assist the industry and the Government in addressing specific critical safety-related issues. Some of these include support for the Institute for Nuclear Power Operations (INPO) and past programs related to the Three Mile Island nuclear power plant. To this end, some of work being done by INPO and the Electric Power Research Institute to help improve human performance in nuclear power plants is very timely and appropriate. DOE has supported some of this work in the past. We believed that this support would be welcome in the future because development efforts to improve operator performance should include the utility industry. Those utilities wishing to turn to the Government for support are likely to find it difficult to turn to the NRC because of the adversary relationship that exists through the licensing process.

B. LWR Extended Burnup

We concur with the objectives stated in the first paragraph on page 110 of the DOE Budget Request for FY 1983. However, we do not concur with the "one vendor" concept.

It is my opinion that reading reports, even if they are complete and provided on a timely basis, is a poor substitute for "hands on" experience. The "one vendor" concept will provide some degree of competitive advantage to the selected vendor because engineering and licensing support for initial large scale implementation will have been singularly subsidized by DOE for this one vendor. In addition, there are significant differences in fuel assembly designs between the NSSS suppliers so that extrapolation of data from a one vendor program to fuel designs of other vendors will be difficult, even if all of the key information is provided in the reports. The basis of the presumption that the other fuel vendors, utilities and EPRI would "carry on the balance of the previously planned program activities without Agency assistance" is not clear to me. The fuel vendor has no incentive since fewer fuel assemblies are fabricated per year. The economic benefits associated with high burnup and longer fuel cycles must be passed on by the utilities to the ratepaying public and, thus, there is no incentive for utility or EPRI funding. It is my opinion that the programs of the "closed out" vendor/utility teams will not be completed.

We are aware, of course, that contracts for these programs do permit cancellation by DOE without cause. However, because of "head end" technology transfers already made by the fuel vendors, we believe DOE has an obligation to proceed in good faith with all programs. These "head end" transfers of proprietary technology have been made public on the presumption that the programs would continue to completion. A "one vendor" program would result in a substantial sacrifice of proprietary information supplied by the other vendors. Should a "one vendor" concept be adopted, it would be logical to presume that the unsuccessful vendors should be compensated for the value of the proprietary technology made public. Finally, a "one vendor" program would jeopardize the precarious vendor-utility partnerships which have been formed.

We do not concur with the "one vendor" approach because it provides a competitive edge to the successful vendor, negates an implicit obligation of DOE that the release of proprietary technology of considerable value would be in return for programmatic completion and it adversely affects utility-government relations.

I suggest we reexamine the theory underlying the Extended Burnup Program in order to put my remarks in context. Combustion Engineering, as well as other fuel suppliers, is participating in DOE sponsored programs aimed at the development and demonstration of high burnup fuel. Electric power generation costs can be reduced by lengthening the time between reactor refuelings and by increasing the lifetime of the fuel. Utilities could implement these new technologies, when available, thus reducing the cost of power to the consumer.

To understand the source of these economic benefits, it is important to realize that there are two separate improvements:

1. Increasing the time between refuelings (increasing cycle length).
2. Increasing the life of the fuel (increasing fuel burnup).

Either of these improvements can be implemented separately. However, the greatest overall benefits are obtained when long cycles are employed in conjunction with high burnup.

The first of these technological innovations, increasing the cycle length, results in reactors being refueled less often (in the PWR, switching from refueling once a year to once every 18-months). Reducing the frequency of refuelings is economically advantageous since more expensive replacement electricity generated from fossil fuels must be used during the period the reactor is shut down for refueling. While utilities have (or are planning) to refuel once every 18-months this is being done without the second technical improvement, increased burnup (longer-lasting fuel). This is because implementing a longer cycle is technologically straightforward; it is the latter improvement which requires some development, and which is the subject of Government sponsored development and demonstration programs.

When only the improvement of longer cycles is implemented, economic benefits result solely from the improved reactor availability. While the reactor is fueled less often, more fuel is replaced at each outage and the fuel still stays in the reactor for three years, so that burnup is not increased. When only the cycle length is increased, requirements for enrichment and uranium actually increase. The resulting increase in fuel cost is smaller than the savings in replacement power, resulting in a net economic benefit for increasing cycle length.

The second improvement, longer-lasting or high burnup fuel, involves designing fuel which can last a longer period of time in the reactor. An increase in fuel burnup from the current level of about 33 MWd/Kg to 50 KWd/Kg would permit fuel operation for four or five years versus the three years which is presently typical for PWRs. This technological improvement, when implemented alone (i.e., in current 12-month cycles), would reduce the amount of uranium required by about 15%. Fueling costs are reduced because of the lower uranium requirements and because of the lower requirements for fuel manufacture and, eventually, disposal.

When both longer cycles and longer lasting fuel are employed, economic savings are realized both from reduced replacement power costs (due to the longer cycle) and from reduced fueling costs (from the longer lasting fuel). In this instance, there is a net reduction in uranium requirements of about 3%, and about a 40% reduction in the quantity of fuel to be fabricated. This reduction in fuel requirements will also result in a corresponding reduction in the quantity of spent fuel discharged after each cycle, and will ameliorate the problem of spent fuel storage at reactor sites where storage rack capacity is limited. A similar reduction would also be realized in the requirements for eventual fuel reprocessing, thereby reducing both the volume and cost of this activity.

The DOE sponsored development programs address, primarily, the demonstration of high burnup fuel. The main thrust of these programs is to provide the basic technical information required for fuel design and to demonstrate satisfactory fuel performance at high burnups.

As noted above, the reduced requirements for uranium, fuel fabrication, fuel storage/disposal, and transportation result in reduced power cost to the consumer. When annual cycles are retained, these reductions in fuel cycle requirements result in savings of approximately 6.8 million dollars per year for each thousand megawatt reactor. With 18-month cycles, savings are larger because of improved plant availability: annual savings of approximately 9 million dollars per thousand megawatt plant would be obtained using present economic assumptions. Simple multiplication of the annual savings per thousand megawatt plant times the integrated number of thousands of nuclear megawatts to be generated yearly by the year 2,000 (only 18 years away) clearly demonstrates the potential integrated cost savings to the ratepayer of many billions of dollars. In order to obtain these benefits without delay, it is essential to pursue, through completion, the DOE development and demonstration programs.

I would like to reemphasize the importance of the Government maintaining the significant advancement made in recent years in establishing relationships with utilities and reactor vendors on existing cooperative programs. These cooperative programs should be maintained, not only because of their direct relevance to research and development in light water reactor technology, but also to retain an investment in an established relationship between the Government and the utility industry which will be necessary for closing the fuel cycle and pursuing the breeder. Loss of confidence by the utilities in the ability of the Government agency to bring its contracting activities to their intended conclusion, even in light of current White House and OMB budgetary restrictions, could result in a large backward step with respect to the current positive relationships which were difficult to achieve and required years to cultivate.

Finally, let me express the opinion that, while in the past the U.S. has been viewed as a world leader in nuclear technology, this position has been challenged recently due to the constantly changing policy of previous administrations. The U.S. is clearly ahead in the area of high burnup fuel and continuation of these programs would help to reestablish U.S. world leadership in nuclear technology. Reduction or elimination of these programs will perpetuate the fears of many nations, as well as those of the utility industry, that the U.S. can no longer be counted upon for such leadership.

C. LWR Radiation Dose Reduction

Programs aimed at radiation dose reduction for individuals involved in operating and servicing nuclear power plants should be pursued with vigor. It is my understanding that the programmatic efforts previously authorized were aimed at the development and demonstration of technology to reduce occupational radiation exposures. One of the major objectives of this effort is to reduce maintenance requirements by improving component reliability. A second objective is to develop improved equipment and techniques for performing maintenance and service operations which should result in lower exposure of operating personnel. These efforts are commensurate with the objective of reducing radiation doses to the lowest level practicable.

Since these programs reduce reactor down times via improved maintenance efficiency, they result in substantial savings to the utilities which are then passed on to the ratepayers. On this basis the cost for such programs should be borne by the public sector.

It is my opinion that zero funding for new programs and close-out of existing programs in FY 1983 should be reassessed by a DOE/Utility Industry/NSSS Vendor/A-E team to determine whether such action is in the best interest of the taxpayer and to identify those programmatic efforts which, if pursued with public funds, would provide the optimum cost/benefit ratio. Those programs which are identified in the low cost/benefit ratio regime should then be ranked in order of priority and should receive consideration in the preparation of the FY 1983 budget.

Senator DOMENICI. Thank you very much.

Mr. Ford.

Senator FORD. Mr. Chairman, I am reluctant to ask any questions. I will waive.

Senator DOMENICI. I have one question for each of you. I am going to submit it and you can answer it at your convenience. I have to be out of here at 11:30. We do have five or six additional witnesses and I want to give them an opportunity.

I do thank you very much for appearing. I think from what the staff tells me that you have given us some excellent testimony. I have not reviewed it yet, but will in due course. We are going to have difficulty because the funding level for this particular entire area in energy function is recommended to be reduced by the administration.

There is some ray of hope that if we can find some savings elsewhere in the long-term sense that there would be strong recommendations to continue the energy function at this year's level, rather than a reduced level. Even that does not do all of the things you have recommended in your specific programs, but it does make the recommended cuts significantly less and in some instances turns the programs to a posture that you all are recommending.

I am sorry that we cannot spend more time on this. You are right, Mr. Chernock, I have been spending a lot of my efforts trying to see if we can put together a broad package and anywhere you look there is not enough money to do everything that everybody wants done in this country, but we are going to keep the discretionary funded appropriated accounts as high as we can. Of course they have taken a real big layback already, for the most part, including energy and many other programs.

Thank you very much.

Our third panel is the Conservation and Renewable Energy programs. We have Mr. Sam Enfield, budget policy analyst, Solar Lobby; Mr. Byron J. Washom, vice president, Solar Thermal Division, Solar Energy Industries Association; Joel Stronberg, director, government relations, Brick Institute of America; Mr. Casazza, chairman of the energy committee, Institute of Electrical and Electronics Engineers, Inc.; Dr. Lloyd R. Lawrence, Jr., director of technical development, Mechanical Technology, Inc., Latham, N.Y.

I will let Mr. Ford open this meeting and if you will kindly try to stay within 5 minutes, we will have some time to ask questions. I will return in just a couple of minutes.

Senator **Ford** [presiding]. I think we will just start at the left here and as the Chairman has indicated earlier, that you hit just the basic important items in your statement. All of the statements you have today will be included in the record in toto and we will try to move along.

So I am not familiar with the names, as the chairman called you. We will start here and identify yourself as you go. We will proceed.

STATEMENT OF DR. LLOYD R. LAWRENCE, JR., DIRECTOR, TECHNICAL DEVELOPMENT, MECHANICAL TECHNOLOGY, INC.

Dr. **Lawrence**. Thank you, sir. My name is Lloyd Lawrence. I am the director of technical development at Mechanical Technology, Inc. We are a high technology research, development, and manufacturing company.

The reason I am here today is we are the prime contractor on the automotive Stirling engine program within the transportation section of the Department of Energy.

At the moment we believe that we do have the leading group in the world now in Stirling engine technology. We have over 100 people actively working on it. Worldwide, there are groups in Europe and Sweden and Germany and the Japanese have announced a major ongoing program with 16 different industrial partners in Japan.

We are the prime contractor on this program that is operating under title III of Public Law 95-238, which is the Automotive Propulsion Research and Development Act.

I would like to discuss very briefly, Senator Ford, the negative affects that have happened during fiscal 1982 as a result of last year's budget reductions and then also the positive things, of course, that have happened in the program that briefly summarize what we would like to accomplish in fiscal 1983.

Mr. Chairman, I am addressing the automotive Stirling engine program and its status. During fiscal 1982, the funding for the program was cut on the order of 50 percent from what the planned funding had been for the program. So obviously that caused us to lose some people and the schedule got extended somewhat.

If I could briefly run through some of the negative results of that, I will then move right into the positive results of the program. The first thing that happened, is very important, is the advanced engine design which is to be done entirely in the United States by the U.S. team was canceled. This is the one that was to meet the goals of the Automotive Propulsion Research and Development Act.

So that did allow us to proceed on an engine that still is a joint engine between us and the Swedish and that engine has had some excellent results. But the advanced engine that would have met the goals of the act, completed the technology transfer and things like that had to be canceled at that time.

Also our component development activities were reduced. The number of engines in the program was reduced. We are no longer allowed to demonstrate our automobiles to the public and all of the work with the automotive industry became severely curtailed.

Even so, we had some major positive accomplishments. Our first engine that was strictly an automotive design was fully tested and characterized 1 month ahead of schedule. It operated at an efficiency of 37.4 percent, which as you know, sir, is more than doubled what the Detroit people will tell you is the efficiency of the present day spark emission engines.

It ran interchangeably on diesel fuel, unleaded gasoline, gasohol, shale oil, and experimental synthetic aviation fuel. It ran interchangeably without changing the engine whatsoever. And we met the 1985 emission standards on all of these fuels without any problem at all.

The engine is still certainly in the experimental stage. It is not a production item. During fiscal 1983, just to wrap up, we would hope to complete a thorough comprehensive testing of this Mod I engine, automotive engine design. We would hope to be able to have one or more operating automobiles. We are now working strictly with U.S. vendors, with various components of the engine, so that the technology transfer is being accomplished. And the final thing for fiscal 1983, which we think is very important, is the design and the development of the Mod II engine which is strictly an American engine.

That will complete the technology to the United States, the transfer to the United States and it will give us the engine that then should meet the goals of the legislation.

In conclusion, sir, the Japanese have announced a $45 million effort now in their press, that is Government funds. We understand it is being matched by industrial funding of an equivalent amount to a factor of two times the amount. They are operating automobiles on Stirling engines in Japan and this program is looking at a wide range of products from the technology.

Thank you very much.

[The prepared statement of Dr. Lawrence follows:]

Testimony of Dr. Lloyd R. Lawrence, Jr.
Mechanical Technology Inc.
Latham, N.Y.
before
Committee on Energy and Natural Resources
Subcommittee on Energy Research & Development
U.S. Senate

Mr. Chairman, my name is Lloyd R. Lawrence, and I am Director of Technical Development at Mechanical Technology Incorporated (MTI). MTI is a high-technology research, development, and manufacturing company located primarily in New York, but including wholly-owned subsidiaries in Port Huron, Michigan, and Anaheim, California. The Stirling engine development team at MTI, consisting of approximately 100 people, is engaged in the development of both kinematic and free-piston Stirling engines for a variety of potential product applications. As far as we can determine, MTI, equipped with unique test facilities, employs the largest group of Stirling engine specialists in the world. MTI formed this team in response to a national need for this advanced, energy-efficient technology, which had been almost solely under development in Europe and Japan.

Mr. Chairman, my company appreciates the opportunity of appearing before this committee. My testimony today consists of a status report on the Automotive Stirling (ASE) Program (funded by the Department of Energy under Title III of Public Law 95-238), a discussion of the negative impact of the Administration's FY'83 budget request, and some observations concerning the relative position of the United States, Europe, and Japan in the development of this promising technology.

Impact of FY'82 Budget Reduction

The original, two-engine generation program called for a peak effort in FY'82 and expenditures of approximately $18M. Actual funds available from the FY'82 appropriation are $8.7M, which, coupled with carry-over funds from FY'82, allow a program level of slightly more than $10M. In addition, FY'82 funding has actually been provided to the prime contractor by a series of monthly contract modifications, rather than the more usual three-or-four-month allocation. The results of these budget actions are as follows:

- the design of the MOD II engine was cancelled (making it impossible to meet the time frame established for Title III, PL 95-238);
- component development activities were significantly reduced with attendant increases in technical risk;
- the number of engines within the program was reduced 50% - from eight to four;
- all efforts on public demonstration of Stirling engines and related educational activities were cancelled; and,
- work related to vehicle integration at AM General was significantly reduced, curtailing the most promising route to exposure of MOD I results to the domestic automotive industry in Detroit.

During FY '82, more than three-million dollars was rescinded from the program, while in FY '82, the budget was reduced by approximately 40%. The difficulties in managing the program because of the manner in which the funding is released is also a major concern. Throughout this fiscal year, funds have been released in small increments, making it very difficult to execute any foreward planning. In some cases, planning is restricted to two-week increments. Releasing funds in small increments has and will cost the Government more money in the long run, e.g., delays in hardware purchases eliminate the ability of obtaining an optimum price and delivery date.

Major ASE Program Accomplishements

In spite of budget uncertainties and funding cutbacks, major accomplishments during FY '81 and '82 include:

- The major program milestone of testing and fully characterizing the first Mod I engine system by September 30, 1981 was completed one month ahead of schedule.
- Three Mod I engines were manufactured, assembled, and tested.
- Approximately 500 test hours were accumulated on the Mod I engine by mid-February, 1982.
- Transfer of Stirling engine technology was increased markedly; viz.
  - Mod I engine testing was successfully initiated in the U.S.A.;
  - more than thirty vendors were established in the U.S.A. for the manufacture of Stirling engine components; and,
  - seven major development rigs were made operational at MTI during the past twelve months (these rigs are an integral part of technology transfer and future technology advancement)
- A Stirling engine was successfully tested with five different fuels without any change in engine hardware. The engine power and performance did not change appreciably, and no change was measured in emissions level as compared to the base fuel of unleaded gasoline.

Multi/Alternative Fuels Test Program

During 1981, a Stirling engine was tested with five different fuels to demonstrate the engine's ability to perform satisfactorily with the fuels while maintaining acceptable emission levels.

- The fuels tested were:
  1. unleaded gasoline;
  2. commercial diesel fuel;
  3. gasohol (90%/10%);
  4. shale-oil-derived marine-diesel fuel; and,
  5. experimental reference-broadened-specification aviation. turbine fuel (ERBS).
- Engine performance (power and efficiency) was not affected more than 10%, and engine hardware was not changed to test the engine.
- Emissions were measured, showing no significant change in their levels with fuel changes.

MOD I Engine Data

Testing of the Mod I engine to date has resulted in the following progress:

- Peak Power = 53.9 kW (72.3 hp) versus 50 kW design
- Maximum Efficiency = 37.4% versus 37.7% design
- Minimum BSFC = 0.37 lb/bhp-hr
- Low fuel consumption region is seven times as large as corresponding region for diesel engines.
- Exhaust emissions are consistent with Federal emission goals:

0.4 g/mi NO_x
3.4 g/mi CO
0.41 g/mi HC

ASE Program Status Summary

In summarizing the status report on the ASE program, despite budget reductions and small, continuous funding increments, the following accomplishments have been demonstrated:

- the program is basically on schedule and within cost;
- the Mod I engine has met and will surpass its performance goals, and,
- the transfer of Stirling technology to the United States is proceeding at a rapid rate.

Foreign Competition

It is a paradox that, while support of the United States Government for Stirling technology is receding in spite of excellent technical success, other countries are actually embarking on expanded programs. Most notable is the recent announcement by the Japanese Government of a multiyear development program as part of the "Moonlight Plan". This program was described recently in a newspaper article printed in Japan.

The newspaper article gives a brief but comprehensive look at Japanese interest and activities, and points out that an experimental device, Melsy 2, is already undergoing engineering tests. Aisin Seiki Company is researching a 50 kW (67 hp) engine (probably for automotive application). The description of Melsy 2 indicates that the Japanese have most likely mastered basic Stirling engine technology. Further, the article's discussion of the petroleum required for Japan's automotive fleet leaves no doubt that the automotive application is their real goal.

Proposed FY '83 Program

The program that we propose for FY '83 builds on the excellent initial success of the Mod I engine and emphasizes the development of the characteristics that will contribute to industrial acceptance of this technolgoy. Specifically, the 1983 program will include the following initiatives:

- Through a comprehensive engine test program, the Stirling engine will be proven in regard to reliability and durability requirements of the automotive application.

- Marked improvements will be made to the Stirling Engine System as it applies to:
    - performance and fuel economy;
    - manufacturing cost;
    - small-vehicle packageability; and,
    - manufacturing techniques.
- Proof of its transient capabilities (as applied to the automotive application) in acceleration, cold-weather operation, and emissions will be established, and alternative fuel evaluations will continue.
- This proof-of-concept program will be made possible in a very cost-effective manner, since existing engine hardware will be used in a majority of cases.
- Final demonstration of the transfer of Stirling engine technology will be accomplished through design, manufacture, assembly, test, and development.

In addition, a special initiative will be made to involve the domestic automobile industry in this program. With the favorable initial acceptance of the Mod I data, we believe it is now possible to set up a constructive dialogue with the industry. In particular, we will ask the industry to identify and quantify the operating goals that will be most meaningful to them in assessing the future role of Stirling engines in their product lines. In our opinion, the time has come for the industry to tell the Government what performance levels must be met in order to progress toward a viable alternative power plant.

Conclusion

Without the base of the ASE program, the United States may find itself unable to compete with foreign products not only in the automotive area, but in every current application that involves a spark-ignition or compression-ignition heat engine as a prime mover. Against this background, MTI requests that the Congress provide $12M for the FY '83 program (i.e., a total of $15M to DOE.)

STATEMENT OF BYRON J. WASHOM, VICE PRESIDENT, SOLAR THERMAL DIVISION, SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. WASHOM. Mr. Chairman and Senator Ford, I am Byron Washom and this morning I am representing the Solar Thermal Division of the Solar Energy Industries Association, which has members of over 400 corporations. Solar thermal division annually seeks to provide DOE and Congress with a single, unequivocal industrial voice as to our research priorities in the five different solar thermal technologies.

Our job has become increasingly more difficult during the past 2 years as has yours. We have negotiated within industry a position that places the highest priorities on those most promising technologies. This has required the drafting of a more reasonable and sound R&D policy than that which is advocated by the administration.

The objectives that we have established deal with a balanced investment partnership between private industry and the Federal Government. As the technology proceeds to the R&D pipeline, the level of private investment and cost sharing by our industry has dramatically increased.

The best case in point is our most mature technology that being of the parabolic trough. Ten days ago one of our corporate members announced the signing of a $75 million 12-megawatt solar thermal electric project with Southern California Edison.

Consequently, our industry association has reduced our budget in the parabolic trough industry in fiscal year 1983, an extremely small amount to cover only that generic material research, and continued data gathering on existing DOE demonstration projects.

We do differ with the administration in that we prioritize those technologies that have a near-term potential to this country, rather than a long-range high-risk basic research that is being advocated and by doing so we seek to preserve not only the public but also the private investment that is in place in these technologies that are close to commercialization.

My detailed presentation, written testimony today notes the significant accomplishments that have been achieved in the solar thermal energy in the past year and I invite you all to study that. Appendix A of my testimony also deals with the negotiated budget that the industry association has drafted.

We have used the 1982 funding levels as a guide post and we have worked with other industry associations and other renewable and conservation fields to come up with what we feel is a total, balanced budget, not only within our own particular field, but in the solar and conservation budget as a whole.

We have shown that the Government-industry partnership is producing new industries with the future of capability of competing on an economically viable basis; as our risk is reduced, the need for Federal budgetary support will be commensuratively reduced. We have demonstrated this to be true in the parabolic trough industry. Industry is increasing its private investment through cost sharing, cooperative agreements, contingency liability agreements and other such instruments.

Our total funding level for fiscal year 1983 that we are requesting is $54.5 million, which is above the administration's level of 18, but is I said a guidepost to the 1982 level. The difference between our level and the administration's level is equal to 8 hours of foreign oil import purchases. But the difference is more than just that.

The difference is also whether or not there will be a solar thermal industry that will compete and supply jobs to this country. I appreciate this opportunity for sharing those views. Hopefully by working these problems out within our industry association, we will allow this committee to be technical advocates rather than technical referees, which we have asked you to do in the past. With pleasure I support implementing this budget and we would welcome any questions you may have at the conclusion of this testimony. Thank you.

[The prepared statement of Mr. Washom follows:]

STATEMENT OF

BYRON J. WASHOM

VICE-CHAIRMAN

SOLAR THERMAL DIVISION

SOLAR ENERGY INDUSTRIES ASSOCIATION

Before the

Subcommittee on

Energy Research and Development

of the

Committee on Energy and Natural Resources

U.S. Senate

April 26, 1982

INTRODUCTION

Mr. Chairman, members of the Subcommittee on Energy Research and Development, the Solar Thermal Division of the Solar Energy Industries Association appreciates this opportunity to address the issue of the deliterous effect that the Administration's proposed budget and policies will have upon the potential of solar thermal technologies providing significant quantities of energy and sources of employment to this nation. Emerging from the technology pipeline are impressive system and subsystem test and evaluations that validate American industry's claims that solar thermal technology will in the near future achieve economic feasibility and technical viability. Continued high risk research is required in the interim and full customer/investor acceptance demands adequate systems level test and evaluation to verify the true capital and operating costs of these innovative systems.

Given the severe federal budget deficit situation that Congress and the Administration faces, the solar thermal industry has begun, and will increase in the future, contributing a larger share of the R&D costs. The industry in FY82 has successfully advocated cost sharing cooperative agreements with DOE in the central receiver repowering program and the parabolic dish Stirling project. The level of cost sharing on these two projects alone are 50% and 27% respectively. Congress and the Administration can anticipate greater levels of cost sharing as the subject technology matures from research and into demonstration; however, enthusiasm for cost sharing is hurt when the Administration proposes repeal of the vital business energy tax credits or yet another federal reorganization.

This testimony seeks to present the solar thermal industry's R&D policy position, the significant technological achievements of the past year, a proposed FY83 budget that can be justified on the basis of true need and potential benefit, and the additional constraints to commercialization that our industry faces.

R&D POLICY POSITION OF THE SOLAR THERMAL INDUSTRY

The Solar Thermal Division of the Solar Energy Industries Association consists of representatives of 22 U.S. corporations involved in the design, development, manufacturing, system integration, marketing, sales, and use of solar thermal devices and systems. These devices and systems supply thermal energy for a wide variety of uses, including industrial process heat and the production of electricity. Nine of these corporations are among the Fortune 500 group. These corporations have offices and facilities in 12 of 15 states, but would expect, in a mature market situation, to buy equipment and components for solar thermal systems from other industrial suppliers who are located in many additional states.

The Solar Energy Industries Association consists of representatives of about 400 U.S. corporations, individuals, and other organizations located in virtually every state. The corporations are involved with the manufacturing and use of a wide variety of solar systems, including active heating and cooling, passive heating and cooling, and photovoltaics. The overall membership represents a wide variety of interests in solar energy from small to very large systems.

The Solar Thermal Division has developed a unified position statement and a series of recommendations regarding its views of the role of the Federal Government in research on and development of solar thermal concepts. We feel that a clarification of the position of the manufacturers and the users of solar thermal systems can be beneficial in helping the Federal Government develop a realistic program that is of benefit to the nation as a whole. Our position statement is based upon a number of important factors that both the Administration and the industry recognize. Among these are the recognition of:

1. The important need to reduce Federal spending as a means of improving the health of the U.S. economy

2. The need to reduce and then phase out Federal involvement in some of the current technologies consistent with the capability of transferring the technology to the private sector under a normal, prudent business climate

3. The fact that commercialization of solar thermal technology rightfully falls within the private sector and that Federal involvement would, after a certain point, be detrimental to the establishment of a sound, free market business environment.

4. The fact that there are a wide variety of potentially viable solar thermal technologies, each in a different stage of maturity insofar as transfer to the private sector is concerned, and that priorities must be placed by industry on these technologies.

A very important factor in defining the degree to which the Federal Government should be involved in the development of solar thermal technology is a concensus on objectives of such work. Therefore, the solar thermal industry, as represented by a wide variety of organizations within the Solar Thermal Division, has developed a unified recommendation in this regard, and it can be expressed as follows:

> The objective of a Federal Program of research and development of solar thermal technology is to identify, evaluate, support research on, and support development of solar thermal devices, concepts and systems which can (1) potentially have a significant impact on achieving energy independence in the U.S., (2) lower and/or stablize the cost of energy in the U.S. and abroad, (3) maintain or improve the quality of the environment, and (4) conserve our oil and natural gas resources.

The goal of this work, which the industry feels should be carried out in large part by industry and which consists of analyses, evaluations, phenomenological investigations, laboratory experiments, bench-scale testing, component design, development and test and, in some cases, demonstration projects, is to achieve a state of readiness in which the technology can be taken over by the private sector and thereby be available as a viable energy option at the earliest possible time. We are emphasizing the point that, since it takes many years before an energy option can make a significant impact on our energy use, R&D which results in near-term transfer to the private sector is to be given the highest priority.

The Solar Thermal Division has identified five major actions, that we recommend the Federal Government should take in order to get as many solar thermal technologies into the private sector as possible in the shortest possible time. In order of priority these are:

1. Retention of the energy tax credit at a minimum of 15 percent and extension of its availability beyond its present expiration of 1985.

2. The retention of the PURPA provision pertaining to the establishment of the independent power producer and raising the unregulated power level to approximately 100 MWe for electric power systems.

3. A FY 1983 budget of $59.5 M that will, among other accomplishments, complete the transfer of the parabolic trough technology and provide a major step toward the transfer of parabolic dish and central receiver technologies to the private sector.

4. Provide for reduced out-year budgets for the central receiver and parabolic dish concepts, budgets that will complete the transfer of these technologies in FY 1985.

5. Provide for increased out-year budgets for longer-term techologies which the Solar Thermal Division recommends be funded at a low level in FY 1983 and FY 1984 until the three above-mentioned technologies are completely in private hands.

The specific budget recommenations that the Solar Thermal Division has prepared for FY 1983 are shown in the attachment along with brief statements of justification.

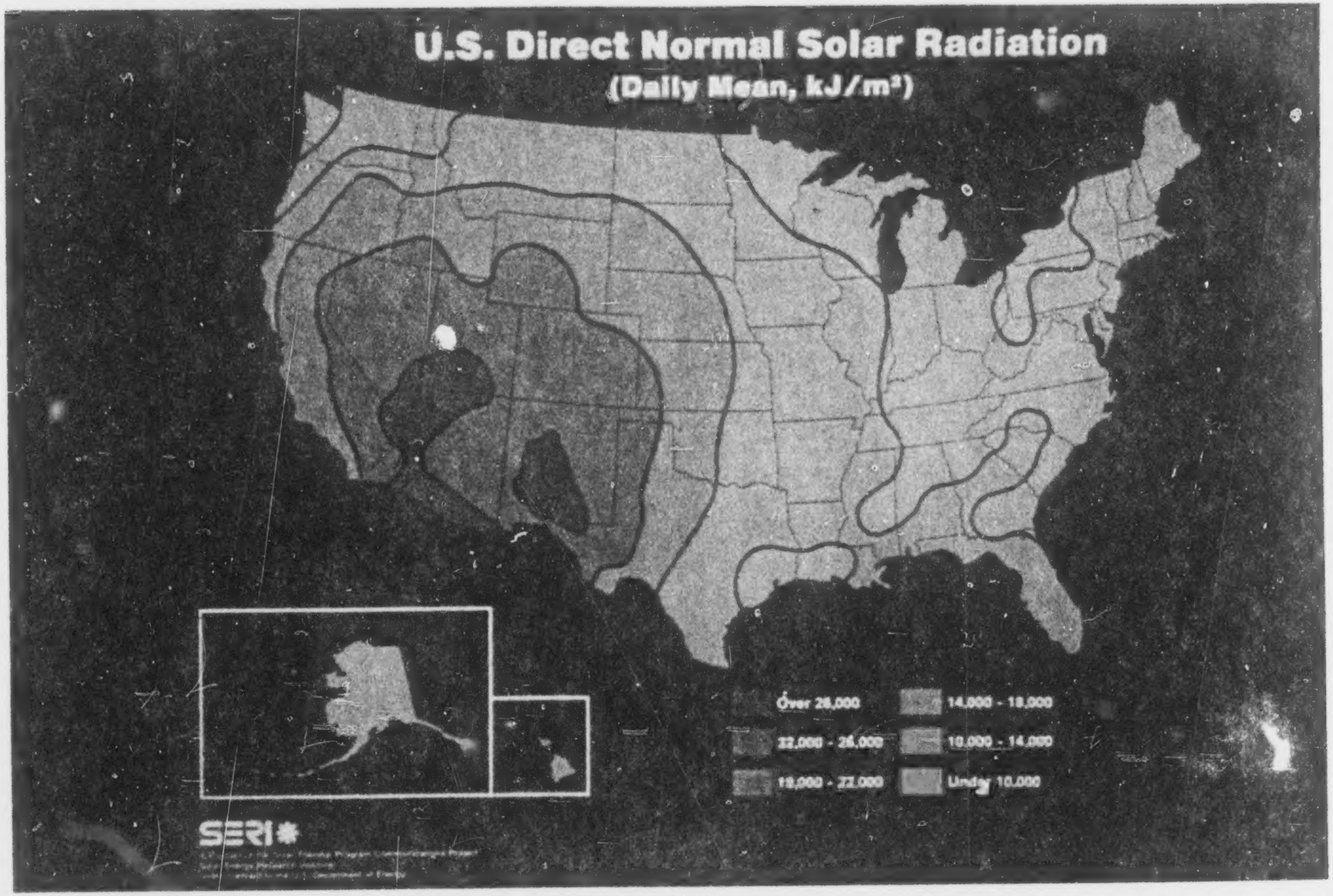
THE SOLAR THERMAL TECHNOLOGIES

Solar thermal technologies track the sun and concentrate solar energy in order to gain higher temperatures and efficiencies than those found in non-concentrating technologies. This ability to concentrate solar energy makes the technology promising in terms of total national energy supply and economic competitiveness. The output from these technologies can occur either in the form of electricity, industrial process heat, mechanical energy, cogeneration or fuels and chemicals. The accompanying maps show the regions of greatest solar insolation in the United States and illustrate that solar thermal manufacturing occurs nationwide.

Solar Thermal Energy Association members are involved in three solar thermal technologies: central receivers, parabolic dishes, and parabolic troughs. Each technology has its own particular design advantages and range of applications and all are capable of supplying clean cost-competitive energy by the end of this decade. Working with the Department of Energy, STEA members have made important progress towards advancing these technologies. We have completed, or are close to completing, an impressive group of systems level projects and supporting subsystem experiments which I would like to highlight for you.

Solar I - Barstow

The construction is completed and initial check-out is underway on the 10 MWe Solar I pilot project. This pilot plant is the largest completed central receiver system in the world and illustrates the leadership of the United States' government and American manufacturers in central receiver technology. The completion of Solar I is significant since this milestone is essential in providing data on the performance, costs, and reliability of central receiver systems. Turbine roll is scheduled for the spring of 1982. This project


U.S. Direct Normal Solar Radiation
(Daily Mean, kJ/m²)
Over 26,000
22,000 - 26,000
18,000 - 22,000
14,000 - 18,000
10,000 - 14,000
Under 10,000
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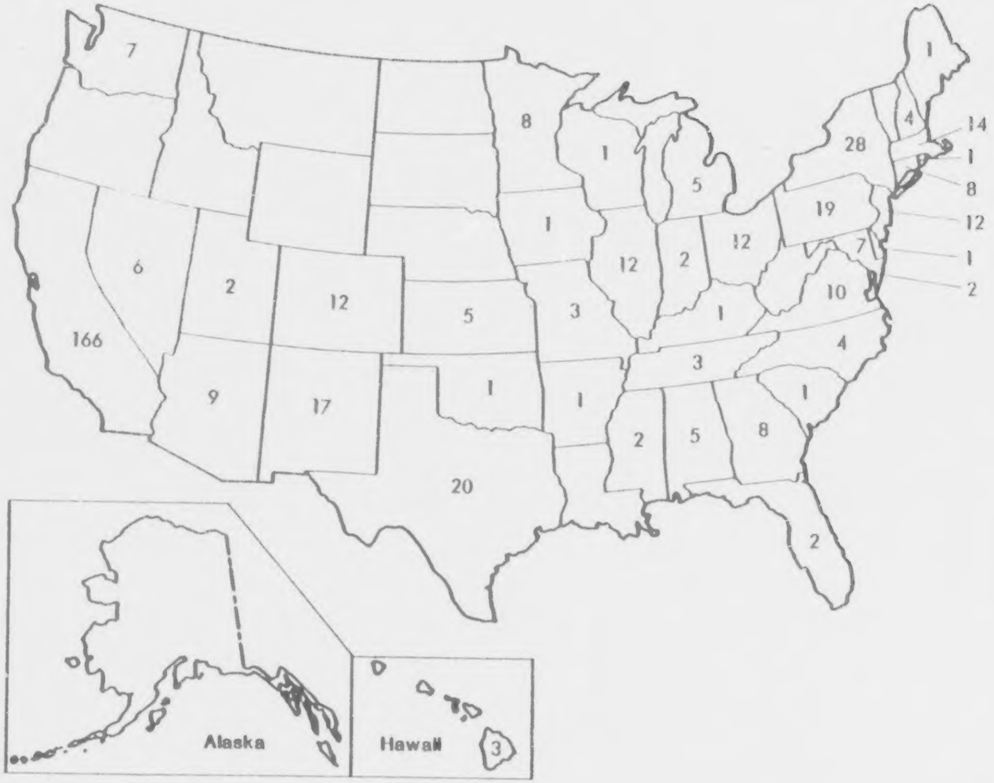
SOLAR THERMAL INDUSTRIAL SUPPLIERS PARTICIPATING IN DOE PROGRAMS (NUMBER PER STATE)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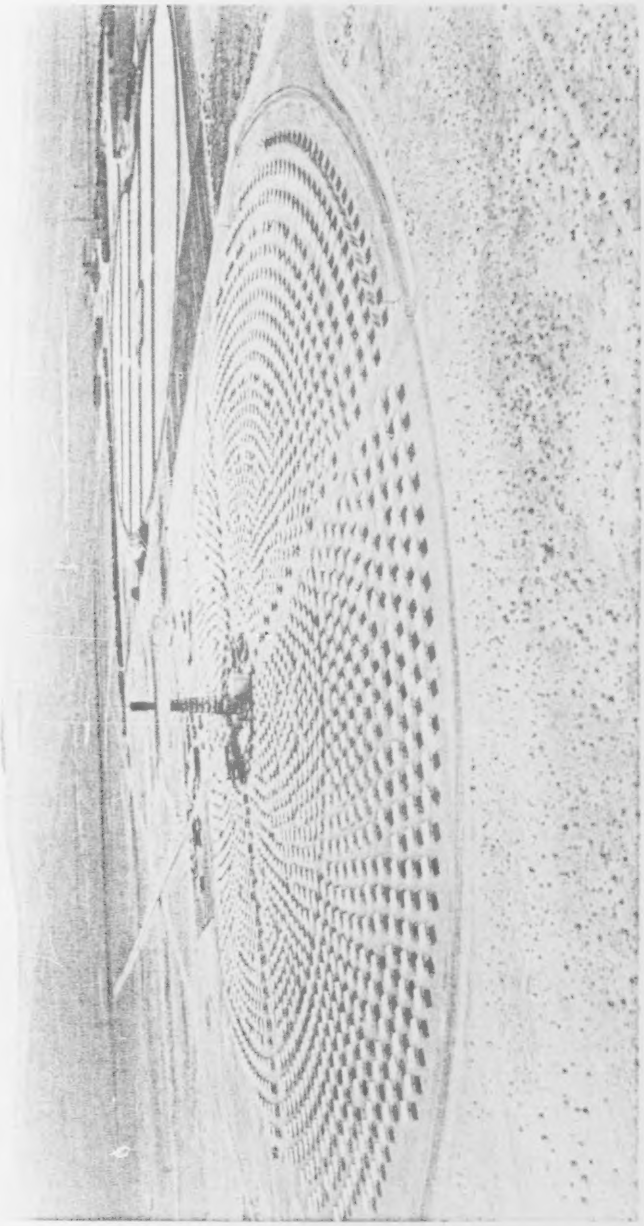
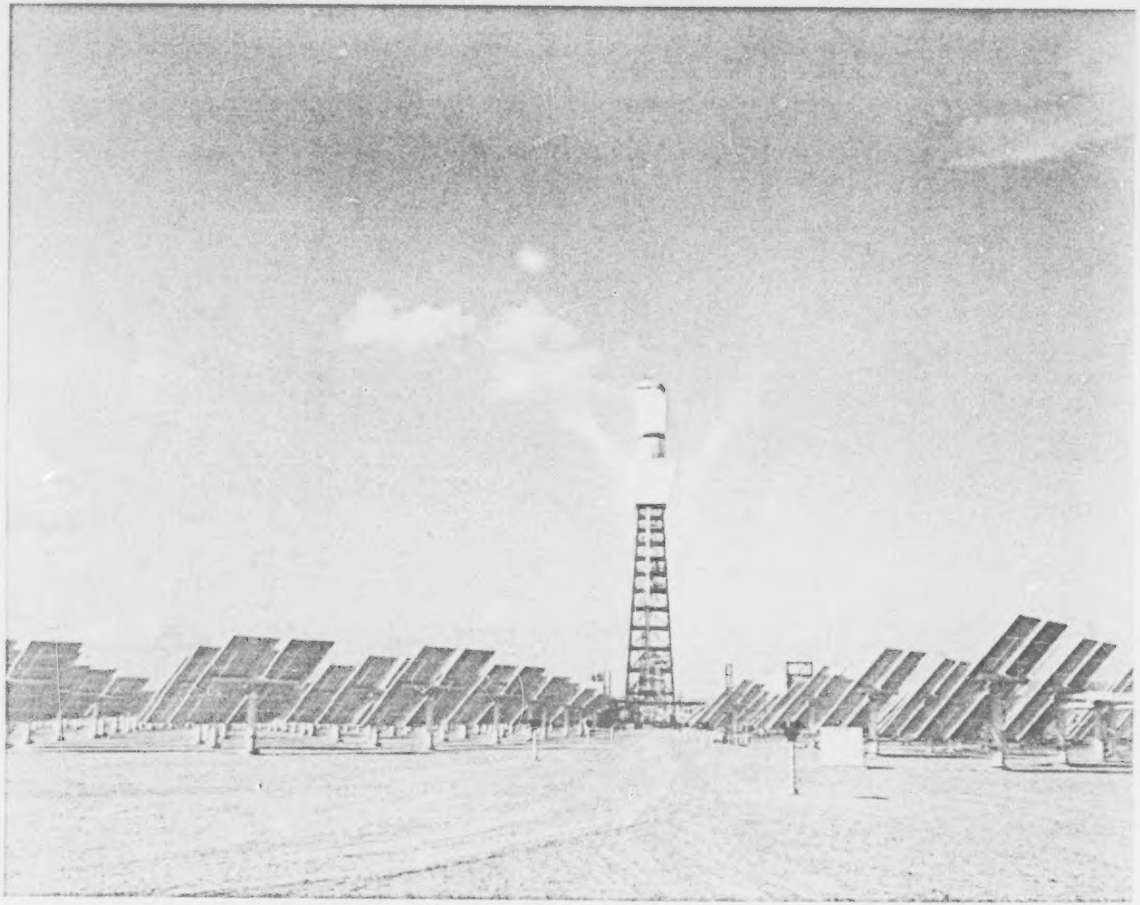


SOLAR ONE 10 MWe PROJECT - BARSTOW CA.



BARSTOW RECEIVER

illustrates the federal role in assembling industry teams for subsystem design, fabrication and test.

Solar I is also significant as a model of cooperation between government and a public utility. The project is a cost-shared cooperative effort involving the United States Department of Energy, the Southern California Edison Company, the Los Angeles Department of Water and Power, and the State of California.

Sodium Receiver Test

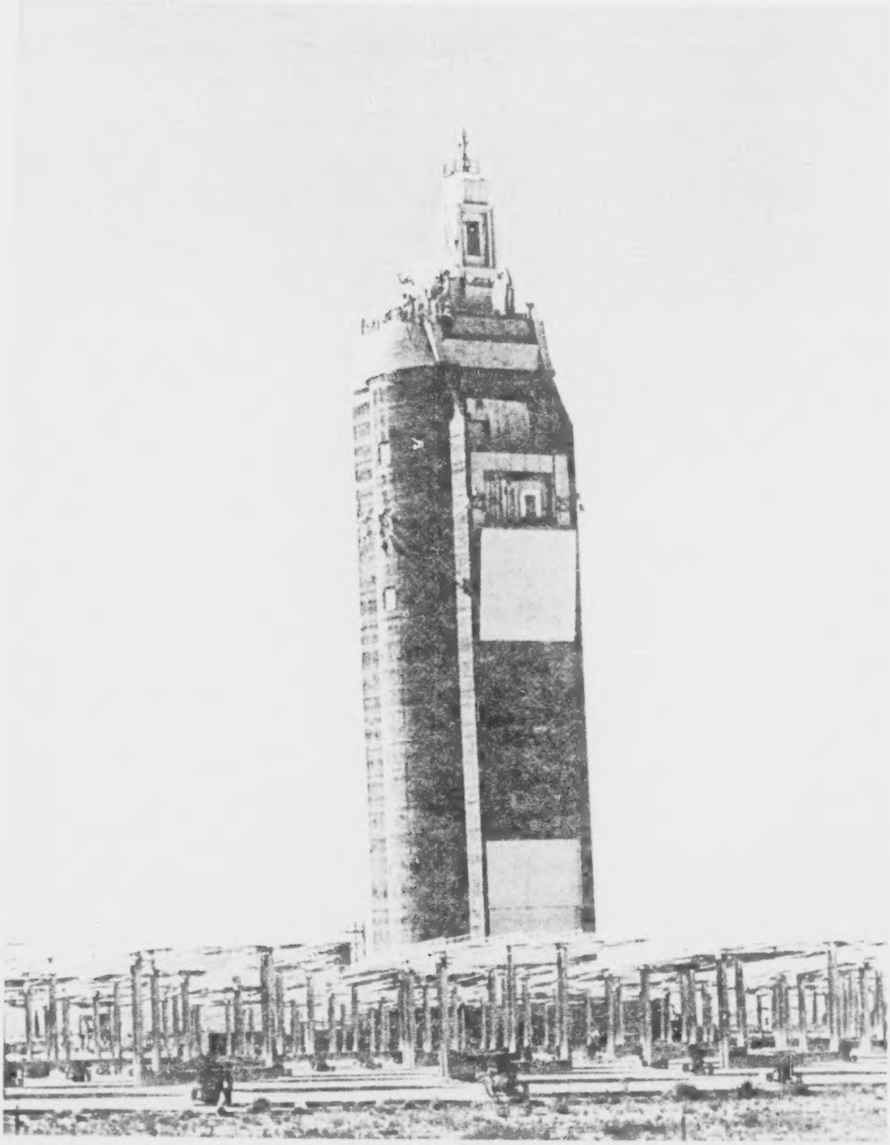
A 2.5 MWt sodium receiver, provided by the Energy Systems Group of Rockwell International at their own expense, is currently being tested at the Central Receiver Test Facility in Albuquerque, New Mexico. The Department of Energy provided funds for the test program and for a sodium loop. Sodium receivers and other advanced central receiver technologies hold the potential to keep the United States at the forefront of this technology, provided that a spirit of cooperation can be maintained between the manufacturers and the Department of Energy, and that the existing test facilities remain available for advanced subsystem test and evaluation.

Second-Generation Heliostat Testing

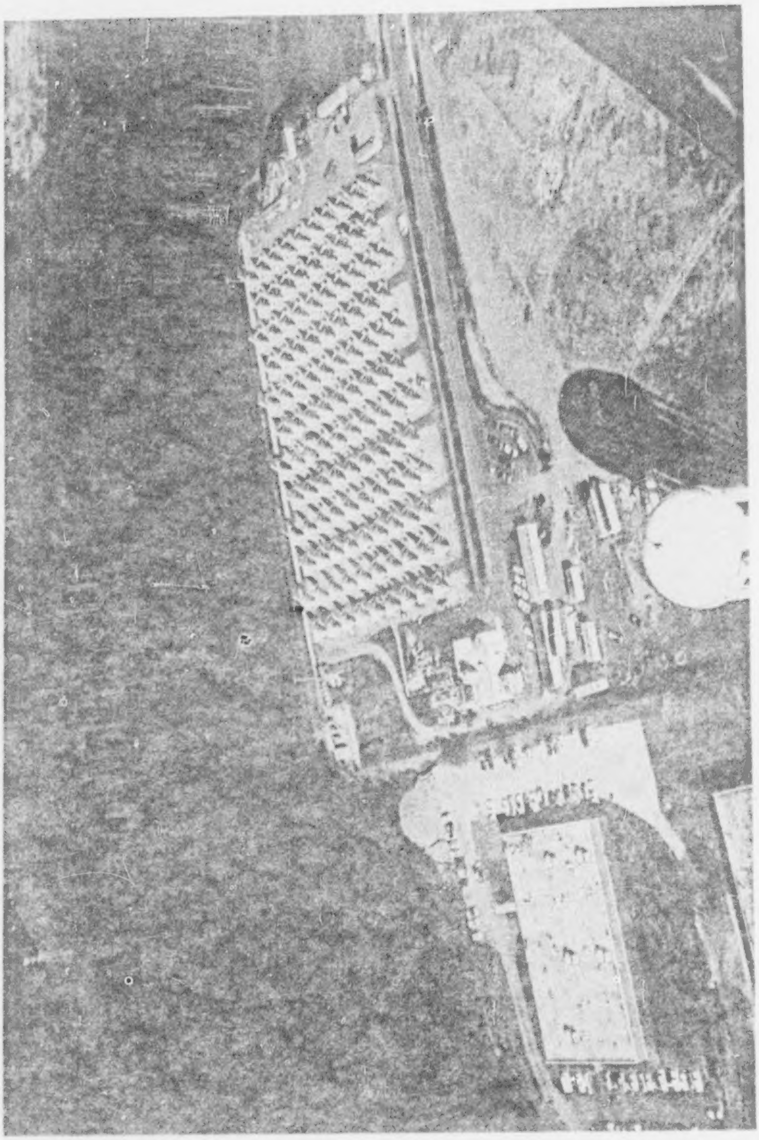
Four industrial firms designed and built second-generation heliostat prototypes which successfully completed test and evaluation at the Sandia National Laboratories. Significant operating parameters were demonstrated that met the 30-year life cycle design goal and the mass-produced cost goal of \$100/m^2 or less.

Shenandoah

The important cogeneration project at Shenandoah, Georgia is rapidly approaching dedication in April. This project is a major milestone for dish technology and will be invaluable for establishing cost and performance parameters for industrial process heat and cogeneration applications. The Shenandoah



SODIUM RECEIVER TEST AT CENTRAL RECEIVER TEST FACILITY - ALBUQUERQUE , NM .

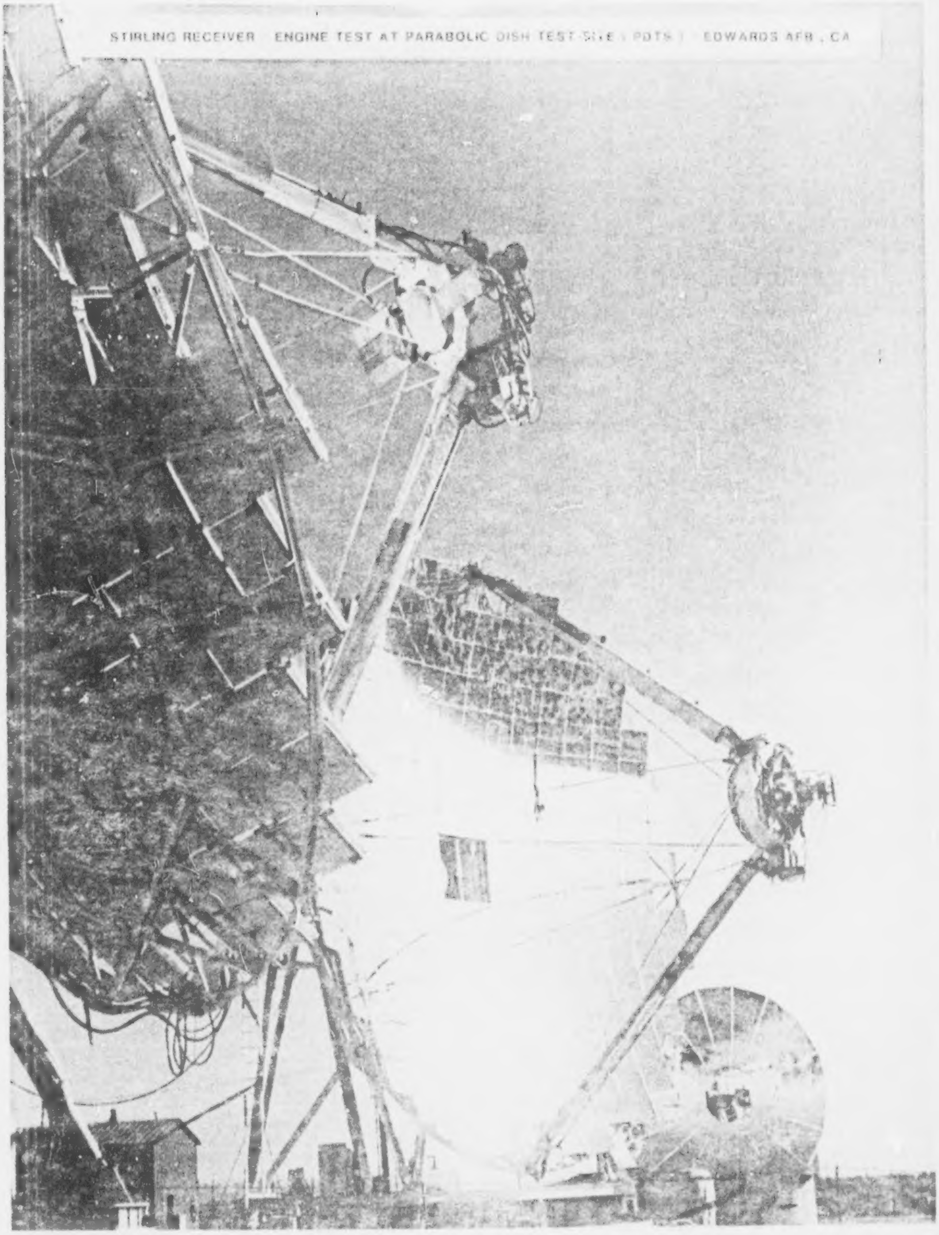


system is capable of supplying the adjacent knitwear factory with 100-400 KWe output with process steam extraction at 330°F for pressing fabric, and heating and cooling for 25,000 square foot of floor space. As with Solar I, the completion of Shenandoah illustrates the effectiveness of the Department of Energy in coordinating the work of many subsystem manufacturers.

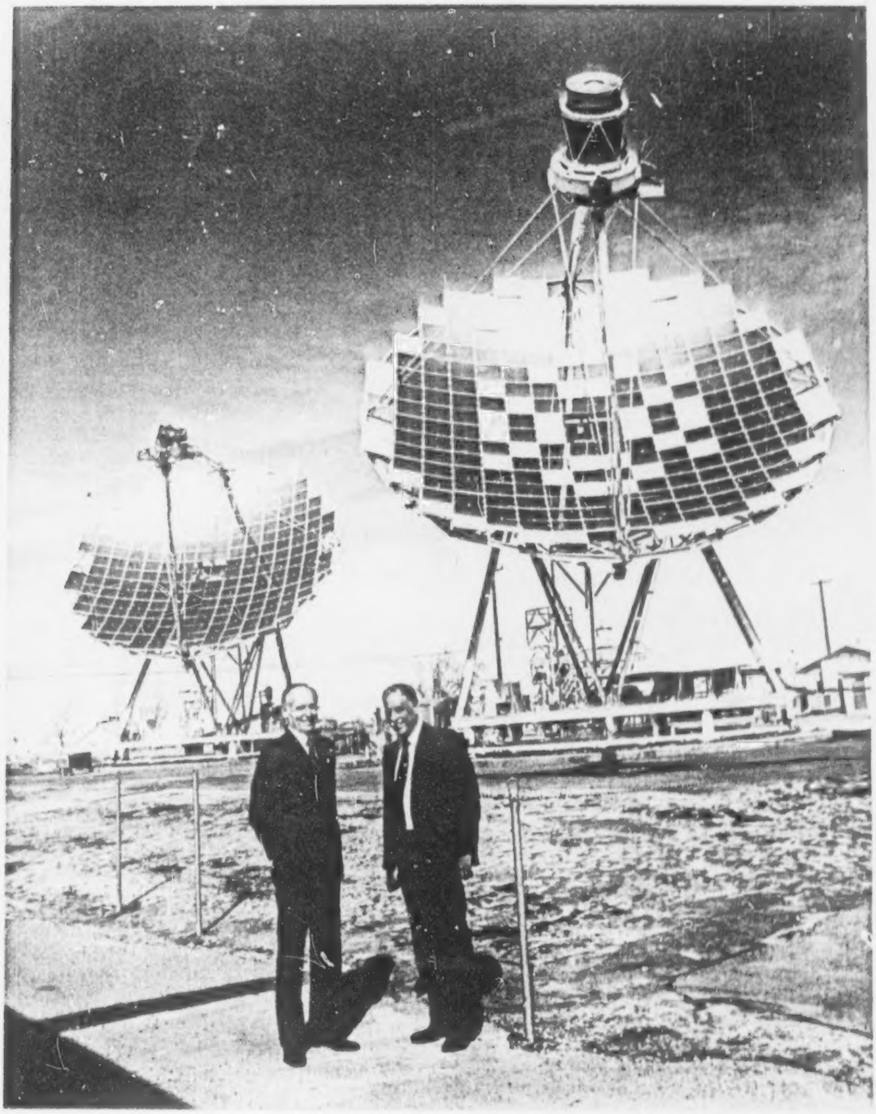
The Shenandoah project is supported through a cost-shared agreement between the Department of Energy and the Georgia Power Company. Georgia Power has been designated as the Plant Operating Authority and will provide the operating staff and daily supervision and maintenance of the plant.

Simultaneous Dish-Electric Receiver and Engine Tests

The Department of Energy has been coordinating the development of Rankine, Stirling, and Brayton engine/receiver combinations capable of highly efficient and reliable electric generation from parabolic dishes. The Energy Research and Advisory Board (ERAB) report recommended that dish module development be continued and noted that high temperature collectors deserve "increased support because of their great versatility." The first power conversion unit to be successfully tested at the JPL Edwards Test Site was the hybrid dish Stirling receiver manufactured by Fairchild Stratos and using a United Stirling 4-95 engine in November 1981. Further testing in February 1982 with a 'solar only receiver' produced a record performance output of 22 kWe and sunlight to electricity efficiencies in excess of 27%! February also marked the first operation of the organic Rankine receiver from Ford Aerospace and Communications Corporation and a Barber-Nichols engine which achieved 17 kWe with an efficiency, of heat into the receiver to electricity out, of 21%. A Brayton engine and receiver are to be similarly tested in September 1982. This testing marks the first simultaneous testing of engine and receiver subassemblies under the program.



STIRLING RECEIVER - ENGINE TEST AT PARABOLIC DISH TEST SITE (PDTS) - EDWARDS AFB, CA



ORGANIC RANKINE AND STIRLING POWER CONVERSION UNITS UNDER TEST AT PDTS - EDWARDS AFB, CA.

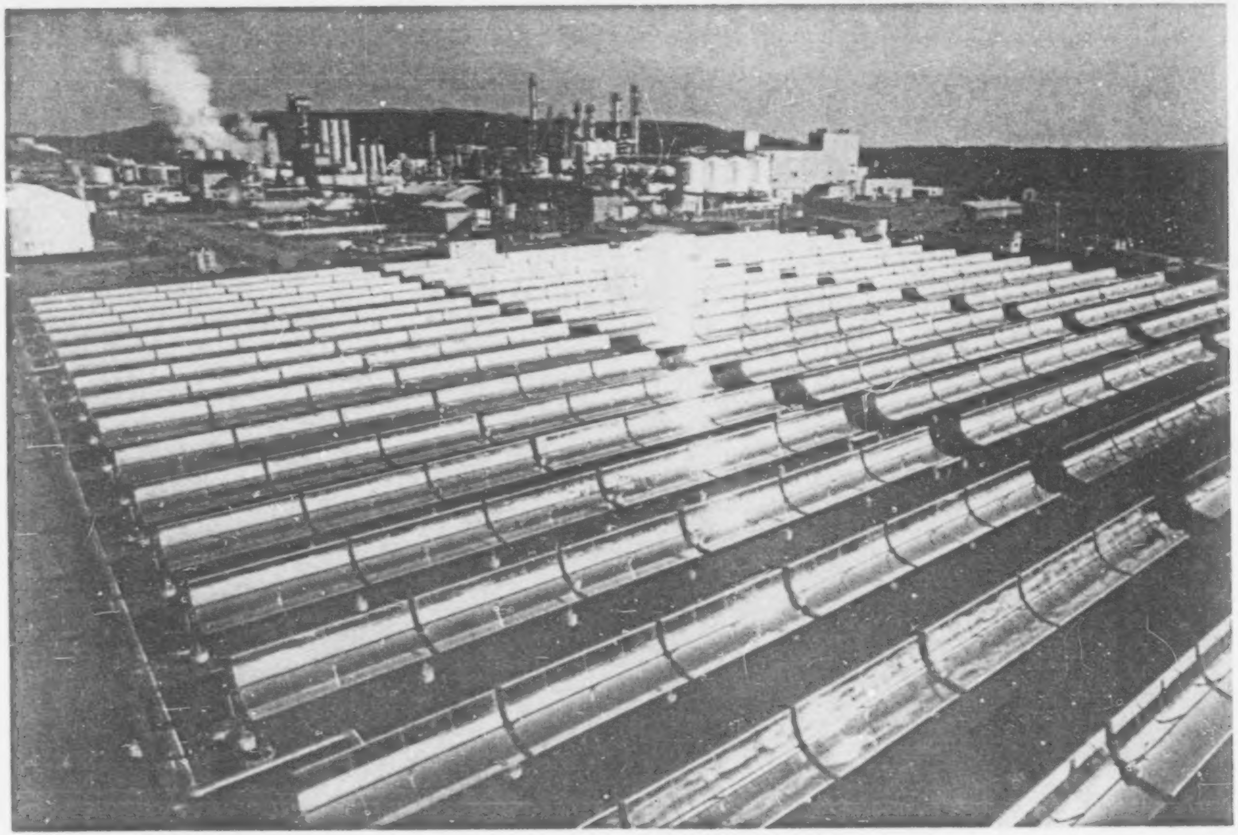
Hardware fabrication is continuing on the dish-Brayton engine and receiver. Two Brayton receivers are under development. Garrett AiResearch is developing an Inconel 625 receiver for applications up to 1500°F. Sanders Associates are designing a ceramic receiver for higher temperature applications. Both receivers are designed for efficiencies as high as 88%. The Brayton engine, manufactured by Garrett Turbine Engine Company, as an associated activity of the automotive gas turbine program is expected to have an efficiency of 30-40%.

Troughs

Parabolic troughs are the solar thermal technology with which we have the most experience and the greatest number of systems in operation. Over three quarters of a million square feet of collectors have been installed as a result of field test experiments, research and development projects and commercial sales. Several STEA members market troughs commercially while others continue to work with the Department of Energy in improving the technology. STEA members have cooperated with the Department of Energy on a number of highly successful industrial process heat installations using parabolic troughs. One recent installation is the United States Steel Chemicals plant in Haverhill, Ohio, which uses 50,400 ft^2 of troughs to provide process steam for polystyrene production.

In successive projects parabolic trough systems have demonstrated increasingly higher efficiencies, higher reliability and lower costs.

The Modular Industrial System Retrofit (MISR) program represents the final step of government support for parabolic troughs. Under MISR, five manufacturers are developing troughs which incorporate the latest advances in trough technology, which are mass producible, and which can be provided in modular units. MISR will validate the modular system design concept and provide an orderly and



INDUSTRIAL PROCESS HEAT PROJECT - HAVERHILL, OHIO satisfactory conclusion to federally sponsored line-focus development. MISR testing is scheduled for the summer of this year.

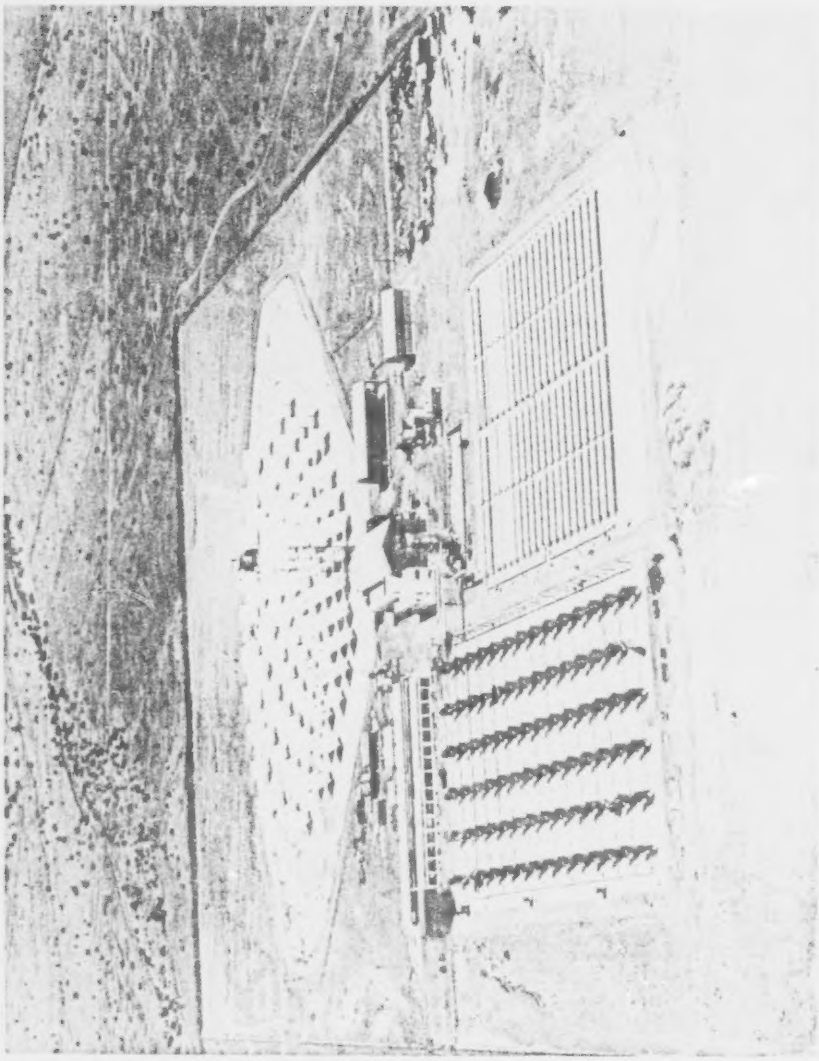
International Energy Agency

Outside the United States, STEA members and the Department of Energy are cooperating in a number of internationally sponsored solar thermal projects. The largest of these projects is the International Energy Agency (IEA) project in Almeria, Spain. In Almeria, two side-by-side 500 KWe solar thermal generating plants have been built. One of these plants utilizes a small central receiver design with Barstow-type heliostats and incorporates a sodium-cooled receiver. The other plant employs an array of parabolic trough concentrating collectors. The parabolic trough project is unique in that it is made up of two collector fields of equal size. One field contains German MAN collectors while the other collectors are from Acurex. The important role of the Department of Energy and Solar Thermal Energy Association members in international projects demonstrates America's leadership in and commitment to solar thermal energy.

RATIONALE FOR SOLAR THERMAL ENERGY

The preceding slides illustrated the direction that the Solar Thermal Program has taken in the past. The future direction of the program, and in a very real sense the future of the technology, is now being considered by this Committee as it examines the Department of Energy's FY 1983 budget request. We believe that the needs of solar thermal technology go beyond the "long-term research and development" that the Administration is stressing at the expense of all other approaches.

The need for solar thermal energy is even greater today than it was when Congress passed the Solar Energy Research Development and Demonstration Act of 1974. Solar thermal systems can provide reliable and cost competitive



INTERNATIONAL ENERGY AGENCY PROJECT - ALMERIA , SPAIN energy. They can produce a broad range of energy products: electricity, process heat and fuels and chemicals. These are the forms of energy which our society is structured upon; solar thermal energy is capable of making an valuable contribution to our national energy mix.

FY 1983 BUDGET REQUEST

The Administration's FY 1983 budget request for Solar Thermal Technology Program is only $18,025,000. This figure represents only a fraction of the solar thermal budgets for the past two years. The total solar thermal budget authority in FY 1981 was over $138M; this year the Congress provided the Division of Solar Thermal Technology with nearly $55M in budget authority. For the second year in a row the Administration has formulated a budget request that is barely one-third of the preceding year's authorization. Last year, the members of this Committee and the Congress realized that the Administration request was not sufficient to meet the needs of the Solar Thermal Program. Industry hopes that this year this Committee will reach a similar conclusion and will take action to assure that the Division of Solar Thermal Technology receives a more realistic budget.

The Administration contends that future federal efforts should concentrate solely on "long-term high-risk research and development." By emphasizing basic research and development at the expense of virtually all other approaches, however, the Department of Energy has chosen the slowest route to technology development. In determining the appropriate budget for the Solar Thermal Program, this Committee must determine whether the purported thrust of the Administration's $18M budget -- long-term, high-risk R&D -- fits the current requirements of the technology.

The Solar Thermal Energy Association (STEA) considers the Administration's budget request inadequate. Appended to my remarks is a comprehensive alternative budget that totals $59.5M. We at STEA have spelled out our rationale for each line item and we feel that our submission represents a realistic and balanced approach to the development requirements of solar thermal energy. For some technologies the $41.5M difference between our budget and the Administration's request may well mean the difference between a viable solar thermal industry, in this country, in the next several years and no solar thermal industry at all.

IMPORTANT QUESTIONS

It is incumbent upon this Committee to consider three questions as it formulates the FY 1983 solar budget for the Department of Energy. The first is whether the Administration's policy has been applied evenly to all energy technologies. The answer to this is clearly no; the Administration has only sought to limit the federal presence in energy development and to rely on private initiatives in those energy technologies that it does not support.

The second question is whether a single economic or technical development has altered the long-term need for alternative sources of energy. Again, the answer is no. The need for solar and other forms of alternative energy is just as real today as it was in 1974 when the government embarked on the current development effort. The only change has been a philosophical one on the part of the Administration.

The final question is how will history judge us. If more support is not provided for solar thermal technologies, the answer will likely be "short-sighted." Right now oil prices are stabilizing, but we cannot allow ourselves to slip into complacency. Rather, we must learn from history. This is the best time to be pursuing alternative energy options and broadening our energy base. The U.S. is still heavily dependent on foreign oil. The amount that this country pays for eight hours of oil imports - $41M - could mean the difference between a vigorous Solar Thermal Program and a program that has been virtually phased-out.

THE THREATS TO SOLAR THERMAL

As I am sure the members of this Committee are aware, solar energy is currently under siege in this country. Just as solar technologies are approaching viability they are being threatened with termination.

From the perspective of the solar thermal industry, the Administration's budget for the Division of Solar Thermal Technology is only one of three threats that we face this year. Perhaps as important as the FY 1983 budget to the future of solar thermal technology, is the proposed elimination of business energy tax credits and the Public Utility Regulatory Policies Act (PURPA) modifications that may be required. The uncertainty surrounding these policies clouds the future of solar thermal systems and makes potential investors very wary. Both the business energy tax credits and the existence of PURPA provide manufacturers with predictable markets and ensure that the technology will be able to enter the marketplace.

The administration has consistently relied upon the range of existing energy tax credits to support the reduction of renewable energy R&D funds. The elimination of business tax credits would deny solar thermal manufacturers effective access to a major sector of the energy market. Appended to my remarks is a short explanation of the need to retain all energy tax credits.

Electric generation is a future solar thermal market, which is why STEA is also concerned with the uncertainty regarding PURPA. The recent court decision vacated two essential elements of the Federal Energy Regulatory Commission's implementation of PURPA. The long-term (20-year) payback of these ventures requires investors to be sure that a reliable market exists before they offer their support. While various solutions to the PURPA dilemma are pending, I want this Committee to be aware of the environment of extreme uncertainty in which solar thermal manufacturers are currently operating.

PRIVATE INDUSTRY CAN CONTINUE THE WORK

The dissemination of this information will inspire user confidence in solar thermal systems and will reduce the risks faced by industry to an acceptable level. Market mechanisms will be able to take over at this point and the solar thermal industry will be able to make final system improvements and finalize production designs.

Once system-wide risks have been reduced, the remaining uncertainties will be within the sphere of normal business operations. Individual solar thermal manfacturers will be in a position to assess their markets and secure financing. In my own experience, the questions I am being asked by investment bankers concern proven system efficiencies and overall operation and maintenance costs. Only when these sorts of issues, which are beyond the scope of individual manufacturers, are resolved, will we begin to see a viable solar thermal industry emerge in this country.

CONCLUSION

Mr. Chairman, today I have shown this Committee the "proof positive" technical dividends of the federal investment in solar thermal technology. They indicate that the government/industry partnership is producing new industries with a future capability of competing on an economically viable basis. As our envelope of risk is reduced, the need for federal budgetary support will commensurately reduce. We have demonstrated this to be true in the parabolic trough industry. Industry is increasing its private investment in these solar thermal technologies by advocating cost-sharing cooperative agreements, contingency liability agreements and similar instruments to increase the value of the federal resources that are available in FY 1983 and in the out years. American industry believes that such efforts should represent a standard by which all projects and technologies are judged. The level of partnership requested of the federal government is

$59.5M which is $41.5M above administration request. This difference is equal to eight hours of foreign oil purchases but equates to whether or not there will be a solar thermal industry to provide renewable energy and a new source of employment to this nation.

The Treasury Department's proposed repeal of the 15% business energy tax credit will eliminate this young industry's ability to continue the technology development on a cost-shared basis and to raise the venture capital or third party financing necessary for the initial commercial projects. The Treasury proposes this repeal in the face of a resolution co-authored by 62 senators and 262 congressmen opposing such a move. Finally, Treasury's own analysis states that, "over 90% of this gain [increased federal revenue] will result from credits for biomass equipment and low-head hydroelectric projects." Industry asks that every member of Congress stand firmly against repeal of the business energy tax credit.

The American public continues to support the ethics of renewable energy technology as a part of the energy supply mix. A Gallup poll conducted during the 1980 Presidential election period identifies renewable energy as the most preferred choice of the American public, while only 3% characterized it as least preferred. Let us continue the government/industry partnership to assure that solar energy makes the national energy contribution that we all envision.

We appreciate this opportunity to offer American industry's position to the Energy Development and Application Subcommittee.

APPENDIX A

SOLAR THERMAL ENERGY ASSOCIATION (STEA)
PROPOSED FY 1983 SOLAR THERMAL BUDGET
(dollars in millions)

		Technology Category			
Item No.	Project	Research	Energy Technology	System Application	Planning and Control
1	Solar I			10.0	
2	Repowering			15.0	
3	Small Community Project (Dish Program)			3.0	
4	Brayton Module Development (Dish Program)		2.5		
5	Research Facilities	4.8			
6	Receiver Development		3.3		
7	Steam Generator Development		2.8		
8	Dish Research	2.5			
9	Shenandoah			1.5	
10	Storage Concept Development			1.6	
11	Concentrator Development (Dish Program)		2.0		
12	Trough Materials		1.0		
13	University Research	1.0			
14	Trough Operations			2.0	
15	Parabolic Dish Hybrid Receivers		1.0		
16	Technology Utilization		1.0		
17	Heliostat Development		1.0		
18	Sunfuels	1.3			
19	SERI Capital Equipment	0.2			
20	Planning and Coordinating				1.5
21	Salt Pond Research	0.5			
		10.3	14.6	33.1	1.5

GRAND TOTAL 59.5

Total Central Receiver = 36.7

Total Parabolic Dish = 14.3

Total Parabolic Trough = 3.0

Total Other = 5.5

59.5

STEA FY 1983 BUDGET JUSTIFICATION

1. Solar I

The operation of Solar I is a crucial step in the development of the central receiver concept and in getting the technology transferred to the private sector. Most, if not all, of the prospective users (see Utility Position Paper dated October 30, 1981) have indicated that Solar I is needed to convince the utility management that the generic concept can meet performance, cost, operating, and durability goals. The industry feels that $10 million is a realistic budget number considering the actual tasks that arise when starting up and operating a first-of-a-kind power system.

2. Repowering

The solar industry feels that the central receiver is close to, but not yet at, the point at which it can be turned over to the private sector. There exists three principle technical/cost barriers to its acceptance. One of these is an uncertainty, of at least 50%, in the cost of central receivers of the types and sizes that will be needed to fill the intermediate demand market (greater than 30 MWe and all-liquid-type coolants). This uncertainty appears at this time to be one of the barriers preventing its introduction into the market place either via direct utility financing, or via other user financing, or via third party venture approaches. A very important step in eliminating this uncertainty is to support, in conjunction with significant cost sharing on the part of the private sector, a preliminary design of at least two solar power plants (either two repowering, two standalone, or one of each). Since there is a reasonably reliable estimate of the cost of preliminary design efforts relative to the estimated capital cost of a project, a budget of $15 million is being recommended for the repowering effort by industry.

3. Small Community Project

DOE has selected six geographically distributed, small communities as candidates for a 150-kW solar thermal experiment. Continued federal budget constraints have reduced this project to the minimum acceptable size and jeopardized the project due to out-year funding requirements. Industry advocates the authorization of $3 million to be equally divided amongst the interested sites. The sites will, in turn, contract directly with the parabolic dish industry to install and operate the maximum number possible of experimental modules by leveraging the limited federal funds with available venture capital. This approach results in no out-year budget requests, a significantly greater level of experimentation with multiple design approaches, and the use of preimarily of venture capital rather than federal funds.

4. Parabolic Dish Brayton Module Development

The Brayton module development represents a team of industrial contractors attempting to design, manufacture, and test a fully integrated parabolic Brayton module. Industry views with great concern that DOE's FY 1982 expenditures for this program are only $0.7 million with over $2 million appropriated for closing out the parabolic dish program. FY 1983 requests are $2.5 million, with the belief that DOE will reevaluate the FY 1982 funding deficiencies. No out-year federal funds would be requested for the Brayton module development.

5. Research Facilities

The solar industry is strongly convinced that solar research facilities are essential to the development of solar energy. The very nature of the solar source, its frequency distribution; its diffuse nature; its variability with time, location, and weather conditions; its diurnal nature, etc., dictate that solar energy concepts, whether long term or short term, high risk or low risk, or involving high- or low-payoff potential, be verified under real solar conditions. The ability to transfer the technology to the private sector at any time will depend to some extent on the degree to which the technical feasibility of the process or component has been verified at a real solar source. In addition, private industry anticipates a need to have facilities available at which testing can be conducted on hardware designed and fabricated by private industry. Any given private organization could not afford or justify keeping a facility active on the basis of the infrequent times at which its own needs must be met. Industry feels, therefore, that this need should logically be met by federal involvement. Of the $4.8 million recommended for this activity, $3 million is needed at the Central Receiver Research Facility in Albuquerque, New Mexico. About $1 million is needed for use by the Solar Thermal Test Facilities Users Association in supporting work at the Advanced Component Test Facility at the Georgia Institute of Technology, at the White Sands Solar Furnace near Las Cruces, New Mexico, and at the Test Bed Concentrators at Edwards Air Force Base. Also, a separate allocation of $0.8 million is recommended specifically for testing of parabolic dish systems on the Test Bed Concentrators at Edwards Air Force Base.

6. Receiver

Of the three barriers impeding the introduction of the central receiver technology into the private sector mentioned above, the second one pertains to performance uncertainties on certain key components.* Both the user industry and the third-party-venture capitalists have expressed concern about the fact that one of these key components, in particular, does not have a counterpart in current industrial practice. This component is the receiver located on top of the tower. In order to remove this barrier and to reduce the perceived risk on this component to the point at which the private sector can pick it up and develop the component for commercialization, the industry recommends a base technology program which includes the receiver as well as two other key components on which industry feels there is undue risk in private-sector development. Insofar as the receiver is concerned, a FY 1983 budget of $3.3 million is considered necessary and should be applied to both the sodium- and salt-cooled concepts. Out-year budget recommendations are $4.1 million for FY 1984 and $3 million for FY 1985. All technology development should be terminated at that point, and no further federal involvement in this area would be considered necessary.

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*The third barrier, which involves the fact that the cost of the first five plants exceeds their value in the free market environment relative to fossil and other energy systems, can potentially be solved by means of the energy tax credit and third-party approaches. Thus, the industry feels that it is essential that the current cutoff date for the 15% energy tax credit be extended from December 1985 to mid-1995. Heliostat production, via the third-part-venture approach, will, by then, be sufficiently high to make the capital cost competitive with fossil systems in the free market environment.

7. Steam Generator

The second key component is the steam generator. Although both sodium and salt steam generators have been built and are at very different stages of development in the U.S., there are certain unique features that are required for the solar application that makes them fall outside of the capability of private-sector development. One of these is the use of the steam generator in the reheater mode. Currently, there are no U.S. manufacturers of steam generators for this application. Another one is that the nominal operating temperatures are considerably higher in the solar application than those that have been used in industry. These factors have led to a recommendation for a FY 1983 budget of $2.8 million, most of which would address salt steam generator development, but some of which would be needed for the sodium system. Out-year budget values would be $4 million and $1.1 million for FYs 1984 and 1985, respectively, with termination at the end of FY 1985.

8. Parabolic Dish Applied Research

A FY 1983 request of $2.5 million in three applied research areas in the parabolic dish program is advocated by industry. The three areas are all high risk and high payoff with generic application to all future parabolic dish technology. The three areas include: (1) ceramic material and manufacturing techniques for high-temperature receivers, (2) improved reflective surfaces, and (3) low-cost system level controls.

9. Shenandoah

Industry feels that a $1.5 million expenditure to complete this project is essential in providing the user community with confidence that the generic dish concept can be operated effectively.

10. Storage

The third component that impedes the acceptance of the central receiver in the longer term is a storage concept that is low in cost and economically viable beyond 12 to 18 h. Conceptual feasibility of at least one thermal energy storage system meeting these criteria has been identified and analyzed. However, technical feasibility needs to be demonstrated before the private sector can take over its engineering development. The design, fabrication, test, and analysis of a test article of sufficient size to verify development potential is estimated at $1.6 million for FY 1983, $0.6 million for FY 1984, and $0.4 million for FY 1985. No funding beyond that time is considered justified. Further development would fall within the private sector.

11. Parabolic Dish Concentrator Development

Significant advancement is required in the parabolic dish concentrator to achieve low cost and long life. The second-generation heliostat study produced significant advancements in the central receiver technology, and it is felt that similar results are possible here if undertaken. In FY 1983, $2 million is requested for this program that would have two or more competitive design efforts.

12. Trough Materials

STEA recommends materials research in the amount of $1 million. Research funds are recommended in order to develop improved absorbers, reflectors, etc. Examples of the types of activities that would be supported are: research on antireflective glazings, lower cost reflectors produced by techniques such as sputtering, and effective absorbers other than black chrome.

13. University Research

Research work carried out by U.S. universities has been useful in the past in identifying promising concepts and processes in solar thermal technology. The industry feels that such work should be continued in FY 1983 and beyond at or near the $1 million level in 1983 dollars. In the view of industry, this research should have a very general goal of identifying, analyzing and carrying out laboratory scale and test facility experiments on processes that can potentially have a significant impact on energy independence, stabilization of energy prices, and reduction of energy imports.

14. Trough Operations

STEA recommends data aquisition and continued operation of existing systems at a $2 million level. It is in the best interest of the line focus industry and the Government that existing federally funded systems be operated long enough to obtain useful data on system performance, degradation with time, reliability, maintainability, etc. Funds are required in FY 1983 to insure that systems which have recently come on line or have recently been upgraded will be operated for a sufficient period to permit useful data to be obtained so as to justify the investment of federal funds in the project.

15. Parabolic Dish Hybrid Receivers

Preliminary results from design experiments of hybrid receivers using natural gas fuel have indicated favorable capacity and operational performances for parabolic dish systems. The more difficult technical development of using low-cost fuels other than natural gas is now required to fully implement this hybrid opportunity in future parabolic dish systems. FY 1983 requests are $1 million.

16. Technology Utilization

Industry encourages DOE to become fully aware of the applicable heat engine and materials research being conducted by DOD. It is felt that the data available from these DOD programs can be applied to the solar programs and that DOE should cooperatively work with DOD to structure and fund these programs accordingly. FY 1983 requests are $1 million.

17. Heliostats

A fourth component for which a small amount of additional R&D is required in order to transfer the technology to the private sector is the glass-type heliostat. Among other technical issues, the adequacy of the seal between the reflective glass element and its backing remains in serious question. The industry recommends a budget of $1 million for FY 1983 to address this issue as well as several others which must be resolved in order to convince the user sector that long lifetime is achieveable for heliostats. No out-year budget needs in this category are expected.

18. Sunfuels

Although the solar thermal industry recommends that R&D in the area of the application of solar thermal processes to the production of fuels and chemicals be conducted, we do not feel that it should have a high priority since it cannot have a near-term impact on stabilization of energy prices or on energy independence. We do feel, however, that a $1.3 million effort is justified, provided it is expanded on research on processes and systems that can potentially apply to a broad range of current industrial processes and products. Even though, for example, a long-term goal of producing hydrogen by means of thermochemical processes appears to be promising, that goal should be reached via analyses, research, and development which can be of use to the U.S. industry in the near term. The industry feels that funding for research and development in the field of fuels and chemicals should be kept at a low level until the nearer-term technology development applying to the parabolic dish, central receivers, and parabolic troughs is at a stage at which it can and will be picked up by the private sector for commercialization. Out-year budgets for sunfuels are, therefore, recommended for increases consistent with the potential impact that the fuels and chemicals systems can have on the U.S. energy situation.

19. SERI Capital Equipment

The solar thermal industry recommends an expenditure of about $0.2 million for use by the Solar Energy Research Institute for the purchase of instruments and peripheral equipment in order to support materials testing on solar thermal systems.

20. Planning and Coordination

Approximately $1.5 million is recommended by the industry for allocation in the area of planning and and coordination of solar thermal activities. These activities should be directed toward all technologies, with emphasis on longer-term activities. The industry opposes activities dealing with cost goals, since such activities tend to have a negative effect on private-sector marketing activities.

21. Salt Pond Research

The solar thermal industry feels that research and development on solar pond concepts, although they can potentially lead to a technology that might have a significant impact on the U.S. energy situation, should be funded at a low level of the order of $0.5 million for FY 1983 and should then increase in out-years consistent with the potential predicted by the early R&D. In part, this recommendation is based upon a recognition of the fact that funding resources on the part of the Federal Government are now and will be limited for the near future, and that we feel that other technologies, further along toward feasibility, should be gotten into the private sector first.

APPENDIX B

THE NEED TO RETAIN THE RENEWABLE ENERGY AND CONSERVATION TAX CREDITS OF PRESENT LAW

October 12, 1981

Prepared by
Nossaman, Krueger & Marsh
1140 19th Street, N.W.
Sixth Floor
Washington, D.C. 20036
(202) 296-7943

For the Solar Thermal Division of the
Solar Energy Industries Association

Executive Summary and Conclusions

1. Repeal of the renewable energy and conservation tax credits, particularly in combination with the massive budget cutbacks in the supporting programs in the Department of Energy, would result in the curtailment of a large number of projects, impede the timely development and expansion of the renewable energy and conservation industries, and result in damage to the economy by reductions in employment and exports.

2. The renewable energy and conservation industries represent a strategic infant sector of the economy. Even with present Government tax subsidies, this sector operates at an economic disadvantage with respect to both conventional domestic energy sources and foreign renewable energy and conservation competitors.

3. There has been no change in the circumstances that led to enactment of the credits in 1978 and 1980 such that the basis for their retention has been invalidated. The credits were passed because of a detrimental national dependence on imported energy. This dependence has not been significantly altered. Oil decontrol, the planned decontrol of natural gas, the establishment of the Strategic Petroleum Reserve, and emergency petroleum allocation regulations, do not reduce the need for fostering a renewable energy industry. Increases in oil and gas prices alone have not produced growth in the renewable energy and conservation market. Moreover, it is not reasonable to expect an infant industry to compete on a free market basis with an international cartel with the power to set prices at rates which will make market penetration of new products financially unsound. The Strategic Petroleum Reserve and emergency allocation regulations solve only short term management problems following import restrictions. They fail to address long term supply issues.

4. The replacement of the ADR depreciation system with the Accelerated Cost Recovery System (ACRS) will not increase the return on renewable energy investments. Also, while the new credit for incremental research and development expenditures is of some use, it is more important at this point to generate sales and production based on current technology. Moreover, because the renewable energy industry has already invested so heavily to reach the production stage, incremental expenses may be small.

5. Investors are willing to put their capital into a venture because of the expectation of profit. The greater the risk presented by a particular venture, the greater margin of profit the investor will require before it is willing to

make an investment. At the present time, investments in renewable energy and conservation projects tend to be of a high risk nature compared to other types of investments. As a result, they do not generally, standing alone, present investors with a sufficient margin of profit to attract the needed investment. The tax credits, in many cases, provide an additional margin of profit to eliminate this insufficiency.

6. The repeal of some or all of the renewable energy tax credits may not result in the net revenue gains predicted by the Treasury after economic (e.g., employment) consequences are taken into account.

7. The Administration's previous statements supporting the credits, reliance on their continued existence as a basis for Department of Energy cutbacks, and explicit Administration recognition that the credits are effective, are inconsistent with proposals to repeal some or all of the credits. Reliance on Administration statements led to support by companies for the Administration's economic program.

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APPENDIX C

Volume 6, Number 10 December 1981

RENEWABLES

Solar-Thermal Electric:
Focal Point for the Desert Sun

Power towers are now being raised in several countries, but the Solar One project in the California desert is perhaps the most critical milestone on the path to commercialization. Information flowing from this 10-MW working laboratory will assist in modifying future designs and provide sound data for evaluating performance and cost. With the benefits of mass production, it now appears that these systems for converting concentrated sunlight to electricity could become competitive with oil- and gas-fired plants in the American Southwest. If research momentum can be sustained, demonstration plants could be on-line by the end of the decade.

Bank upon bank of mirrors move slowly under the southern California sky, tracking the sun and concentrating its radiation on the receiver of a power tower nearby. Jutting 310 ft (94.5 m) above the desert floor, the tower looks a little like a rocket awaiting liftoff.

In a sense, the Solar One pilot plant, a joint DOE-utility project located in the Mojave Desert near Barstow, California, is a launchpad, but not for extraterrestrial travel. As the first U.S. 10-MW (e) solar-thermal pilot plant, it might well become the critical milestone for a joint industry-government commitment to the solar-thermal central receiver concept.

As Gerald Braun, director of DOE's Solar-Thermal Technology Division, has noted, the planned turbine roll at Solar One early in 1982, the first test of its electric output, represents a major event in efforts to advance this new technology to the point of commercial development.

Robert Hughey, director of DOE's Solar Energy Division office in San Francisco, adds that of all the solar-thermal conversion concepts, central receiver plants hold the greatest potential for electric utility applications. DOE and EPRI studies show that if carried through the test and demonstration cycles, solar-thermal central receiver power plants may be competitive in the Southwest with gas- and oil-fired plants.

"Of all the direct solar options under consideration by electric utilities today," says John Bigger, EPRI's solar-thermal project manager, "the prospects for solar-thermal conversion look the best." He adds that the most recent EPRI survey indicates that U.S. electric utility interest in solar-thermal energy is greater today than ever before, with utility support and participation in 68 solar-thermal projects this year.

What are the vital steps that remain to be taken for solar-thermal conversion to move from a promising prospect to an operating, commercial reality? Bigger sees two key steps: performance demonstrations and corporate commitments. "Pilot plants, like the Solar One project and five other central receiver tests starting up in Western Europe and Japan this year and next, are expected to contribute performance information and operating experience to encourage supply industries and electric utilities to make commitments to this emerging technology," says Bigger. This information and experience is needed to confirm the estimates of cost and performance made in earlier studies. Corporate commitments are needed to foster mass production, and hence economies of scale, in the construction of key components, such as heliostats (the mechanical tracking mirrors that reflect and concentrate solar energy).

A working laboratory

Deserts make ideal locations for solar-thermal conversion plants not only because the sunshine is abundant, which is critical, but also because land is relatively inexpensive and available. The Solar One site comprises 130 acres at Daggett, California, about 12 miles southeast of Barstow, California. It is owned by Southern California Edison Co., a sponsor of the project with DOE and the Los Angeles Department of Water & Power, the nation's largest municipal utility. The California Energy Commission is also a participant. In addition to providing the site, SCE joined LADWP in designing and building the steam turbine generator and other conventional components of the plant at a cost of about $21.5 million. McDonnell Douglas Corp. and Martin Marietta Corp. are the major contractors.

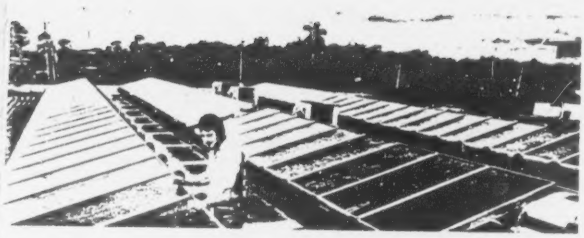
Solar One's start of operation is planned for mid-1982. The first two years of operation will include experimental testing of the major subsystems and evaluation of the operation and maintenance costs and requirements. This period will be followed by power production tests, which are designed to obtain longer-term operating, maintenance, and reliability data. The intent is to make more accurate estimates of commercial solar-thermal plant costs and performance.

When operating, the plant will use 1818 heliostats, each containing 12 separate mirror facets. Preprogrammed coordinates will be used to allow the heliostats to automatically track the position of the sun across the sky. The concentrated beam of solar energy reflected from the heliostats will be aimed at the central receiver on top of the structural steel tower. The energy focused on the central receiver will convert water to steam to operate a conventional turbine generator, producing up to 10 MW of electricity, the amount of power needed to supply a community of 7000–10,000. At night or during periods of high winds, the heliostats will be moved to the stow position horizontal to the ground, with the reflecting surfaces facing downward.

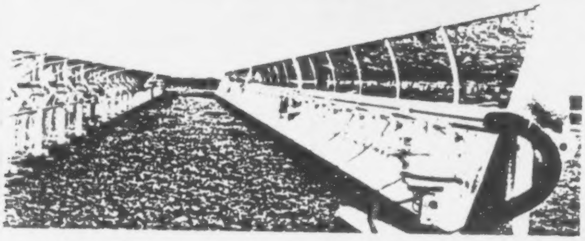
Solar One will serve as a laboratory, providing information on which many future decisions will be based. Information on equipment reliability and failure, for example, will be coupled with system performance data. These data will be vital to the decision makers planning and designing the next solar central receiver installations, perhaps in the 30–100-MW (e) range. In addition, the Solar One test will provide electric utility personnel with first-hand experience, both in the operation and in the maintenance of the new technology. Utilities will monitor the information, experience, and performance data that develop from operation of the Solar One plant.

Next step: repowering

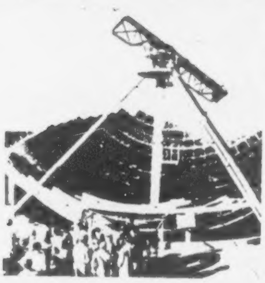
EPRI's Bigger believes information learned at Solar One, together with data from other ongoing experiments and central receiver pilot plants outside the United States, will pave the way for the next major step toward commercialization of solar-thermal conversion technology: implementation of a larger, precommercial project, probably a repowering plant. *Repowering* is a term applied to the concept of adding a solar-thermal conversion front end to an existing conventional fossil fuel power plant. Based on seven conceptual design studies recently completed (six were funded by DOE), the prospect exists that selected power plants



Flat plate collectors, like the rooftop unit providing energy for an air conditioning system at a Florida Power & Light Co. facility, are used to collect solar energy for water heating and the space heating and cooling of buildings.

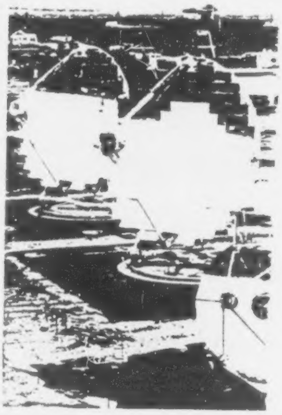


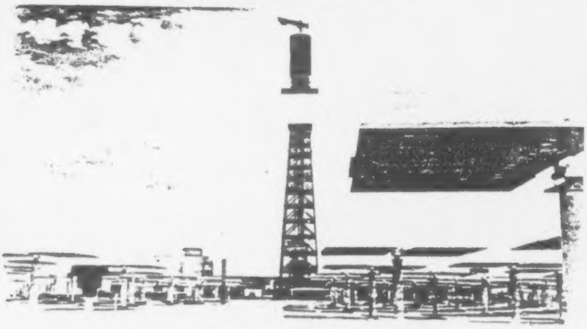
Line focus troughs reflect solar energy onto heat transfer fluid moving through a focal line. Such systems are demonstrating their capabilities in providing thermal energy for a wide range of industrial and agricultural processes.



Line focus bowls being tested under DOE sponsorship use a large number of mirror segments attached to a spherical structure to concentrate solar energy on the fluid moving along a line. This concept differs from the others in that the heat receiver moves rather than the reflectors. Heat collected in a number of bowls may be used for heating or cooling buildings, steam production, or small-scale electricity generation. (left)

Point focus dishes, like these DOE-funded test units, achieve high temperatures by using a number of mirrored reflectors attached to a single parabolic structure to focus intense solar heat on a receiver located at the focal point. Heat collected in this manner may be used to generate electricity, to provide energy for heating and cooling buildings, or to provide energy for many industrial and chemical processes. (right)





Central receivers, like this one near Barstow, California, achieve the high temperatures required for large-scale electricity generation by reflecting the energy received by hundreds of mirrored surfaces onto a single point, or receiver. The high temperatures achieved by central receiver units may also prove economic for many fuel and chemical production processes.

could be repowered and energy from the sun might replace as much as 20% of the expensive oil and gas now being burned. Future projects would demonstrate the concept of solar-thermal conversion in a conventional operating environment, and if the 20% savings in fossil fuels could be achieved at acceptable cost, such plants might be attractive.

Still, the cost of such systems remains a critical question. While the rising cost of fossil fuels is an obvious economic plus in the solar-thermal equation, it is also clear the cost of building the solar power plants is a major stumbling block. Estimates of the cost to modify and build solar repowering plants runs from $1500 to $4000/kW (in 1980 dollars), assuming a heliostat cost of about $\$250/\text{m}^2$. EPRI analyses indicate that heliostats must be available for about half that cost if commercial solar-thermal plants are to compete with those now burning gas and oil for electricity generation. Even greater cost reductions would be needed to compete with coal-fired generating plants. Much of the development work supported by DOE's Solar-Thermal Program and under way in private industry is aimed at reducing costs by designing more efficient components and systems. Results of DOE's Second-Generation Heliostat Program were announced recently. This work covered a two-year test and development program with four potential heliostat suppliers. The results indicate the price of these new heliostats, if ordered in sufficient quantities, could approach the $\$110/\text{m}^2$–$\$150/\text{m}^2$ range.

DOE has also examined a number of advanced central receiver concepts; the performance of each is considered to be better than the first-generation water-steam system now being installed at the Solar One pilot plant. These concepts include advanced water-steam systems, liquid-metal and molten-salt systems, and a combined-cycle concept. With DOE support, Martin Marietta has developed a 5-MW (th) molten-salt receiver which was designed, built, and successfully tested at DOE's central receiver test facility (CRTF) at Sandia Laboratories in Albuquerque, New Mexico. A smaller-size liquid-metal (sodium) receiver panel was designed and built with private industry funds; it will undergo solar testing in the late-1981 through early-1982 time period.

Developing hybrid plants

The cost of developing solar-thermal energy is affected by an inherent handicap shared by all the emerging solar electric options: reliance on an intermittent source. How does a utility compensate for the lack of energy at night or on overcast days? To circumvent this problem, EPRI studies have concentrated on the Brayton-cycle gas-cooled solar-thermal system in a hybrid mode. Such hybrid power plants would use solar energy when the sun is shining, then burn oil or gas to generate electricity on cloudy days or at night. In contrast, the federal program is emphasizing thermal storage as part of the solar power plant. (The Solar One facility at Barstow was designed to have a thermal storage system capable of producing 7 MW (e) for four hours, using an oil and rock mixture inside a 60-ft-diameter tank storage vessel.)

Unlike the Rankine-cycle water-steam systems (such as is installed at Solar One), Brayton-cycle systems use air, helium, or other gas mixtures as the heat transfer fluid in the solar receiver (*EPRI Journal*, June 1979, pp. 18–21). Such systems, under development by EPRI and DOE, have been successfully tested at DOE's CRTF and at other solar-thermal test facilities at the Georgia Institute of Technology and the U.S. Army's White Sands Proving Ground.

Whereas Rankine-cycle systems operate in the temperature range of about 1000–1100°F (538–593°C), with pressures in the 1000–2000-psi (6.9–13.8-MPa) range, solar Brayton-cycle receivers have been successfully tested with air at temperatures in the 1500–2400°F (815–1315°C) range. These higher operating temperatures have the advantage of offering potentially higher efficiencies; they have the disadvantage of encountering material problems, usually at about 1500°F (816°C). To address these material problems, EPRI and DOE have sponsored studies aimed at developing and using high-temperature metallic alloy and ceramic components in Brayton-cycle receivers.

EPRI full-system experiment

The next step in the EPRI Solar Program is an experiment involving a complete Brayton-cycle solar-fossil hybrid system to generate electricity. Called the solar-fossil hybrid full-system experiment, the system is now being designed and will use the 1-MW (th) receiver previously tested at CRTF from October 1978 to March 1979, which was developed for EPRI by Boeing Engineering & Construction.

The commercial gas turbine to be used in the full-system experiment will be equipped with a parallel trim combustor, which allows fossil fuels to supplement the sun in a solar-fossil mode of operation and increases the system's operating flexibility and reliability. The parallel trim combustor concept was developed under a separate EPRI contract with Solar Turbines, Inc., which is bringing this experience to the full-system experiment as a subcontractor to Boeing.

In accordance with EPRI's goal of providing a link between research, development, and commercial implementation by the electric utilities, Public Service Co. of New Mexico is coordinating activities of the recently formed Utility Test and Operations Group, whose members represent about a dozen utilities, most of them located in the Southwest. This group will provide technical assistance to Boeing and will conduct the experiment during the solar operating phase. The experiment will give electric utility operating and engineering personnel firsthand exposure to a complete solar-fossil hybrid generating system.

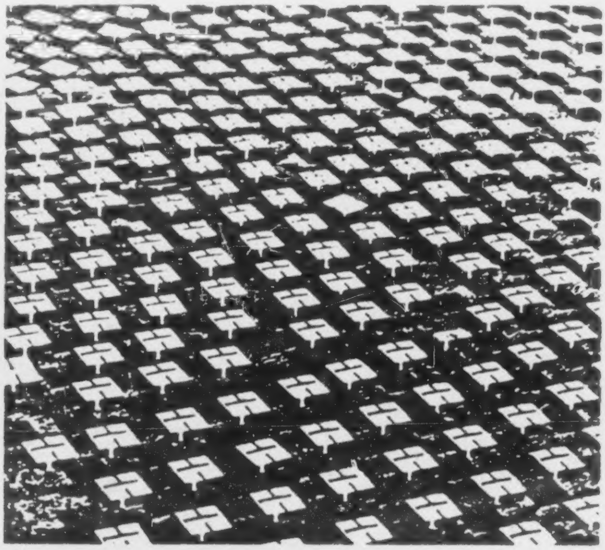
Several of the southwestern utility companies participating in this experiment have also been taking part in DOE's repowering projects, and they can be expected to play a lead role in the development of solar-thermal conversion.

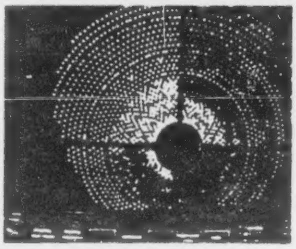
Information garnered from the full-system experiment and Solar One will be combined with data from other central receiver projects coming on-line throughout the world to advance solar-thermal central receiver technology and understanding.

Dishes, troughs, and bowls

In addition to the central receiver or power tower approach to solar-thermal energy conversion, considerable interest has also developed in various forms of dispersed or distributed solar-thermal systems. Such systems fall into two broad categories: point focus and line focus systems.

Point focus systems are similar to the power tower concept to the extent that the solar energy is focused on a central location. Rather than hundreds of heliostats focusing a solar beam at a distant receiver on top of a tower, however, a single mirrored tracking device in the shape of a parabolic dish captures the solar energy and focuses it on a receiver mounted a few feet above the dish. A special facility for testing dish systems and components is located at Edwards Air Force Base in California and is operated by Jet Propulsion Laboratory. Also, at Shenandoah, Georgia, DOE is currently building an array of parabolic dish concentrators to be used for electricity





Solar One, a 10-MW installation located near Barstow, California, is the nation's first solar-thermal central receiver electric generating station. A field of 1818 heliostats, controlled by computer, tracks the sun throughout the day and reflects its energy onto the receiver, where steam is produced. The steam is then sent either through heat exchangers for thermal storage and later use or to a conventional steam turbine that generates electricity. EPRI researchers believe information coming from the Solar One central receiver station will help advance this emerging technology and can lead to additional industry and utility commitments to continue its development.

SOLAR-THERMAL RESEARCH IN OTHER COUNTRIES

Interest in solar-thermal energy systems is not confined to the United States but is being actively pursued in a number of industrialized nations. Some of the major work currently under way includes the central receiver pilot projects described below.

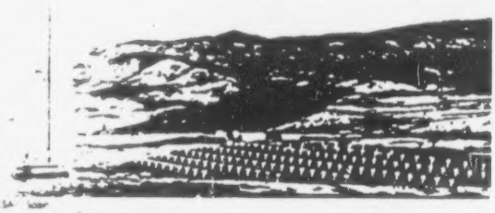
Almeria, Spain: The International Energy Agency has funded the construction of a 500-kW (e) small solar power system that uses liquid metal (sodium) as the heat transfer and thermal storage fluid. A cavity receiver located on top of a 140-ft (43-m) central receiver heats the sodium to 975°F (525°C). The 93 heliostats in the field provide 430 ft² (40 m²) of surface area and were supplied by the Martin Marietta Corp. The project is funded by several European countries and the United States; startup was in September 1981. This IEA installation also includes a (nominal) 500-kW (e) line focus system for a direct comparison of performance with the adjacent central receiver.

Almeria, Spain: A 1.2-MW (e) central receiver system is under construction and scheduled for completion in late 1982. Called CESA-1, the unit uses a cavity receiver to produce 975°F (525°C) steam. A German and a French firm each supplied 150 heliostats with 430 ft² (40 m²) of surface area. The unit has a thermal storage capacity of 3 MWh (th) and uses Hytec as the storage fluid. Funding is being provided by the Spanish Joint Committee for Scientific and Technological Cooperation and the United States.

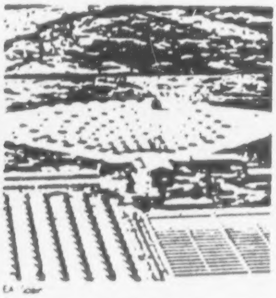
Adrano (Sicily), Italy: Eurelios, a 1-MW (e) central receiver solar power plant, began operation in May 1981. The cavity receiver sits on top of a 180-ft (55-m) tower and produces steam at 950°F (510°C). A 30-minute thermal storage subsystem is used to even out cloud transients, and Hytec is the storage fluid. The project was developed by a consortium from Italy, Germany, and France.

France: In the Themis project, a 2-MW (e) central receiver solar power plant will use molten salt as the transfer fluid, heated to 975°F (525°C) by solar energy reflected by 200 heliostats, each with a surface area of 560 ft² (52 m²), aimed at the cavity receiver. The storage system has 4 MWh (th) of capacity and uses Hytec as the storage medium. The project is scheduled to begin operation early next year.

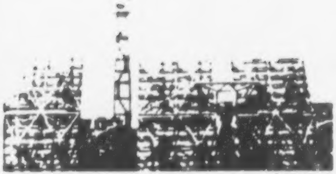
Nio Town (Nagawa Prefecture), Japan: A 1-MW (th) water-steam central receiver power plant went into operation earlier this year. The field consists of 807 heliostats, each providing 172 ft² (16 m²) of surface area; it reflects the sun's rays into a semicavity located on top of a 197-ft (60-m) tower and produces saturated steam at 480°F (250°C). Pressurized water is used as the thermal storage medium for 3 MWh (th) of heat storage. The project is completely funded by the Japanese Agency of Industrial Science and Technology and the Ministry of International Trade and Industry. □



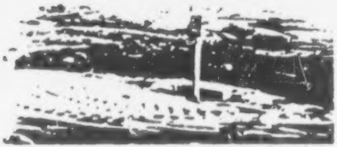
CESA-1 solar



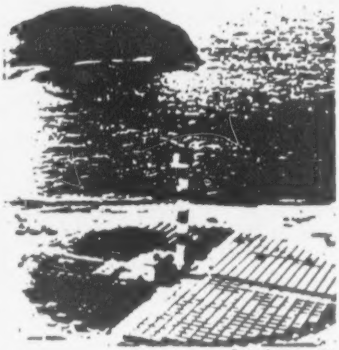
IEA solar



Eurelios, Italy



Themis, France



Project Sunshine, Japan

generation, heating and cooling, and low-temperature steam production for a nearby knitwear plant.

Line focus, or trough, systems consist of a series of specially designed cylindrical or parabolic troughs lined with mirrors to collect and concentrate the sun's radiation. Under federal sponsorship, a number of the line focus systems have been installed at industrial and research sites. These systems usually operate in the lower temperature ranges, 200–600°F (93–316°C), adequate for providing industrial process heat, for operating small turbine generators, or for some specific commercial or industrial applications. Such uses might include irrigation pumping, for example, or steam injection for secondary oil recovery. Recent EPRI analyses indicate that line focus systems, because of temperature limitations, do not look favorable for large-scale electricity production.

Outlook

After an investment of many hundreds of millions of dollars in solar-thermal conversion technology since the early 1970s, where are we now and where do we go from here? Of all the solar-thermal technologies, only one is in commercial use: flat-plate collectors for water and space heating. The others are in various stages of development.

Of those solar-thermal technologies in development, the line focus systems have the most experience in field installations. This experience has been gathered in industrial and commercial process heat applications, where the temperature requirements are lower than those of utility power generation needs.

The point focus systems are the least developed of the solar-thermal technologies, but with further development they may have the capability for utility applications because they can achieve temperatures high enough for efficient electricity generation. Because the point focus systems are modular, they hold the potential for serving a wide range of electric requirements and may lend themselves to incremental installation.

Considerable resources have been expended on the development of central receiver systems, both in the United States and abroad. The technology holds significant promise for electric utilities as stand-alone plants that contain thermal storage systems, as solar repowering units tied to existing oil- and gas-fired units, and as new solar-fossil hybrid plants. It is also significant that a number of electric utilities have become directly involved in the studies and projects conducted by both DOE and EPRI.

With the level of federal solar program support sharply decreasing and future federal involvement increasingly cloudy, the corporate commitment of funds from suppliers and utilities needed for continued development will be determined in large measure by the analysis of results of solar-thermal conversion projects in the field today. These include not only the U.S. projects but also those experiments under way abroad, whose results will now become even more crucial. As these important data are collected, the next critical step in the development of solar-thermal power will be to ensure the broad and accurate dissemination of this information.

Further reading

Penetration Analysis and Margin Requirements Associated With Large-Scale Utilization of Solar Power Plants. Final report for TPS75-611, prepared by Aerospace Corp. August 1976. ER-198.

Closed-Cycle High-Temperature Central Receiver Concept for Solar Electric Power. Final report for RP377-1, prepared by Boeing Engineering & Construction. January 1978. ER-629.

A Methodology for Solar-Thermal Power Plant Evaluation. Final report for RP648, prepared by Westinghouse Electric Corp. August 1978. ER-869.

Design and Fabrication of a 1-MW(t) Bench Model Solar Receiver. Interim summary report for RP377-2, prepared by Boeing Engineering & Construction. August 1979. ER-1101-SY.

A Description and Assessment of Large Solar Power Systems Technology. Livermore, Calif.: Sandia National Laboratories, August 1979. SAND79-8015.

Solar-Thermal Conversion to Electricity Utilizing a Central Receiver, Open-Cycle Gas Turbine Design. Final report for RP475-1, prepared by Black & Veatch Consulting Engineers. March 1978. ER-652.

This article was written by Dan Van Atta, manager, Public Information. Technical information was provided by John Bigger, Advanced Power Systems Division.

Senator **Ford**. Thank you very much.

STATEMENT OF SAM ENFIELD, BUDGET POLICY ANALYST, SOLAR LOBBY

Mr. **Enfield**. Good morning. My name is Sam Enfield. I am budget policy analyst for the solar lobby and I want to thank you for the opportunity of addressing you today. As you can well imagine, the current administration's proposal for the DOE renewable energy program is of very serious concern to the solar lobby.

The solar lobby now has over 48,000 members. They are, as a whole, well educated and successful professionally. They are also solidly behind the Federal effort to develop renewable energy resources. In this last regard, I think they represent well the attitudes and opinions of the American public.

In this regard, I would like to submit for the record a paper examining public attitudes on energy development that was delivered to the American Association for the Advancement of Science in January. It documents continued strong popular support for solar and renewable energy development.

The strongest message I have to bring today is a concern over the lack of balance in this administration's energy policy. In recent years Congress has enacted a broad-based energy policy that develops and promotes a wide range of energy supply sources.

It is the kind of program that will provide the country with the mix of energy options it needs. And within such a mix, renewable energy interests are willing to compete. Our ability to compete, however, has been jeopardized by proposals to drastically reduce R&D work on renewable technologies and to eliminate the most critical tax incentives for the purchase of renewable energy systems.

The administration's justification for eliminating the energy tax credits is that world oil prices, and decontrol of domestic oil prices, have created a climate in which renewables can compete. Our response has been that these conditions, and policy changes made with respect to them, are relevant to all energy technologies, not just renewables.

The administration's justification for drastically reducing the renewable energy R&D budget is that the technologies have been sufficiently developed and that the private sector can carry them through to commercialization on its own.

Mr. Chairman, this is simply not the case. We have seen real successes resulting from the DOE program, and some renewable technologies are entering the market. But the administration is proposing a $500 million in reduction in the Federal commitment to renewable energy development within less than 2 years' time and it is simply unrealistic to expect the private sector to assume this kind of financial responsibility, particularly in today's economy.

This is not to say that renewable energy interests expect a continuation of budget levels enjoyed during the Carter administration. We have been willing to absorb our share of the reductions imposed on Federal expenditures overall and on energy development in particular.

Last year, the solar lobby and renewable energy industry group proposed a budget level roughly two-thirds of the level originally proposed for 1982 by the Carter administration. The final appropriation was roughly one-half of that Carter proposal. This year, we are encouraged by this committee's early support for a continuation of 1982 levels for energy development programs into 1983.

We believe that this level of effort is needed and justified to continue essential work on emerging renewable energy technologies and to insure an adequate return on the very substantial Federal investment in renewables made so far.

I think the international renewable energy market offers a good demonstration of how important continued Federal support for renewables development can be.

Generally speaking, the United States holds a technological edge in renewable energy. We also dominate the world market for renewable systems. But a number of other countries are now substantially increasing their expenditures in this area and working hard to commercialize renewable technologies.

Japan, for example, is openly eyeing the United States as a market for its systems. It is ironic that the technologies these countries are commercializing were largely developed through U.S. efforts. It would be unfortunate to see foreign companies enter, and perhaps dominate, the U.S. renewables market with our own technologies.

There are ways to address this situation. One would be to provide our industry with the international marketing assistance provided as a matter of course for foreign industries by their governments. Perhaps the most important way, however, is to continue the timely development of our own renewable energy technologies. Not only would this help sustain our leadership in renewable technology worldwide, it would also enhance the contribution that renewables can make in this country.

This raises the other fundamental disagreement that the solar lobby has with this administration's renewables policy. And that is the redirection of it away from commercially related activities to help the private sector make full use of the results of federally supported research.

Any research and development program should be mindful of the practical applicability of its results. This involves carrying the R&D process to the point at which its products become both understandable and useful to those who will apply them. In the case of industries composed of small, diverse companies, which is characteristic of many renewable energy industries, this is particularly important.

Recently, the solar lobby has collaborated with a number of interest groups representing industry and user perspectives on the buildings sector to outline an integrated research program in building energy use.

The principle of putting research results into forms useful to the actual practitioners is an important part of our approach to this area and it is important throughout the renewable sector as well. I would also like to ask, Mr. Chairman, that this proposal be entered into the record of this hearing.

Mr. Chairman, we are looking for ways to support important renewable energy activities through private means. We are working with the Conservation and Renewable Energy Inquiry and Referral Service, formerly the National Solar Heating and Cooling Information Center, but still operated by the Franklin Institute, in an attempt to develop a plan by which that service can support itself through its commercial value to renewable energy consumers and businesses.

Federal funding for that operation is needed in fiscal year 1983, but hopefully not after that.

As we did last year, the solar lobby is working with industry groups, including the Solar Energy Industries Association and the Brick Institute of America, to develop a detailed budget proposal for the 1983 DOE renewable energy programs. I am hopeful that this proposal can be finished in the next week or so and that the record of this hearing might be left open long enough for its submission.

Thank you again, Mr. Chairman.

[The prepared statement and additional material submitted by Mr. Enfield follows:]

TESTIMONY OF
MR. SAM ENFIELD
OF THE
SOLAR LOBBY

Mr. Chairman, members of the Subcommittee, I first want to express my appreciation for the opportunity to address you today. As you may well imagine, the current Administration's 1983 budget proposal for the DOE Renewable Energy Program is of very serious concern to the Solar Lobby.

The Solar Lobby is a nationally-based organization with over 48,000 members. They are, on the average, well educated and successful professionally. They are also solidly behind the Federal effort to develop renewable energy resources. In this last regard, I think they fairly represent the American people as a whole, who still clearly place a priority on renewable energy development.

For example, in January, a panel of sociologists from Washington State University presented a paper to the American Association for the Advancement of Science. In it they cited three separate opinion polls which consistently reflected the American people's clear preference for the development of solar and renewable resources as energy supply alternatives for this country. I would like to request that their paper be included in the record of this hearing following my testimony.

MR. CHAIRMAN, AS YOU WELL KNOW, THE ENERGY PROBLEM -- IF NOT A CRISIS -- IS STILL WITH US. ENERGY SECRETARY EDWARDS ACKNOWLEDGED IN A RECENT INTERVIEW WITH "THE ENERGY DAILY" THAT FALLING OIL PRICES ARE DIVERTING US FROM THE DRIVE TO DEVELOP NEEDED ALTERNATIVE TECHNOLOGIES. HE THEN SPOKE, HOWEVER, ONLY OF THE NEED TO PURSUE A NUMBER OF SYNTHETIC FUEL PROJECTS.

THIS REFLECTS THE ONE ASPECT OF THE CURRENT ADMINISTRATION'S ENERGY POLICY THAT CONCERNS US AT THE SOLAR LOBBY MOST SERIOUSLY, ITS LACK OF BALANCE. IN RECENT YEARS, CONGRESS HAS ENACTED AN ENERGY PROGRAM THAT EITHER CONTINUED OR BEGAN DEVELOPMENTAL WORK ON A WIDE RANGE OF FOSSIL, NUCLEAR, RENEWABLE ENERGY AND ENERGY CONSERVATION TECHNOLOGIES. THIS IS THE KIND OF BROAD-BASED PROGRAM THAT CAN BEST PRODUCE AN OPTIMAL MIX OF ENERGY SUPPLY OPTIONS FROM WHICH THE MARKET MAY SELECT. AND WITHIN SUCH A RANGE OF TECHNOLOGIES, RENEWABLE ENERGY INTERESTS ARE WILLING TO COMPETE.

OUR ABILITY TO COMPETE, HOWEVER, HAS BEEN THROWN INTO QUESTION BY ADMINISTRATION PROPOSALS TO DRASTICALLY REDUCE R & D EFFORTS IN THE RENEWABLES AREA AND TO ELIMINATE THE MOST CRITICAL TAX INCENTIVES FOR THE ACTUAL PURCHASE OF RENEWABLE ENERGY SYSTEMS. THE ENERGY TAX CREDITS ARE ESSENTIAL FOR OFFSETTING THE RELATIVELY HIGH FRONT END COSTS ASSOCIATED WITH

RENEWABLE ENERGY SYSTEMS. THE R & D WORK IS NEEDED TO BRING THE TECHNOLOGIES TO THE POINT WHERE THEY CAN BE VIABLE PRODUCERS OF ENERGY IN WHICH USERS CAN HAVE CONFIDENCE.

THE JUSTIFICATION GIVEN BY THE ADMINISTRATION FOR REMOVING THE TAX INCENTIVES FOR RENEWABLE ENERGY SYSTEMS IS THAT WORLD OIL PRICES -- AND DECONTROL OF DOMESTIC OIL PRICES -- HAVE CREATED A CLIMATE IN WHICH RENEWABLES CAN COMPETE. OUR RESPONSE HAS BEEN THAT THESE CONDITIONS ARE RELEVANT TO ALL ENERGY SUPPLY TECHNOLOGIES AND INDUSTRIES, AND THAT POLICY CHANGES MADE IN RESPONSE TO THEM OUGHT TO BE APPLIED MORE BROADLY. ONE WONDERS, FOR EXAMPLE, IF CONTINUING TAX INCENTIVES FOR OIL AND GAS DRILLING IS MORE IMPORTANT THAN CONTINUING INCENTIVES FOR THE CONVERSION TO A NON-DEPLETABLE AND ENVIRONMENTALLY SAFER RESOURCE BASE.

THE JUSTIFICATION GIVEN FOR REDUCING THE RENEWABLE ENERGY R & D BUDGET IS THAT THE TECHNOLOGIES HAVE BEEN SUFFICIENTLY DEVELOPED AND THAT THE PRIVATE SECTOR CAN CARRY THEM THROUGH TO COMMERCIALIZATION. MR. CHAIRMAN, THIS IS SIMPLY NOT THE CASE AT THIS POINT WITH MOST RENEWABLE TECHNOLOGIES. WE HAVE WITNESSED SOME CONSIDERABLE SUCCESSES AS A RESULT OF THE DOE RENEWABLE ENERGY PROGRAM, AND A NUMBER OF PRODUCTS THAT WERE DEVELOPED OR REFINED THROUGH THAT PROGRAM ARE ENTERING THE MARKET. THESE

INCLUDE PRODUCTS SUCH AS ACTIVE SOLAR SYSTEMS FOR WATER AND SPACE HEATING,PASSIVE SOLAR BUILDING MATERIALS AND TECHNIQUES, SMALL WIND TURBINES, ALCOHOL FUEL PRODUCTION PROCESSES, PHOTOVOLTAIC SYSTEMS (FOR REMOTE APPLICATION IN THIS COUNTRY AND ABROAD), AND PARABOLIC TROUGH SOLAR THERMAL CONCENTRATING DEVICES. MANY MORE PROMISING RENEWABLE ENERGY TECHNOLOGIES ARE STILL IN DEVELOPMENT AND WILL NOT BE COMMERCIALLY ACCEPTED UNTIL THEY ARE FURTHER REFINED AND SUCCESSFULLY DEMONSTRATED. THIS GROUP INCLUDES ACTIVE AND PASSIVE SOLAR COOLING SYSTEMS, CONCEPTS AND COMPONENTS, PHOTOVOLTAIC SYSTEMS THAT ARE CHEAP ENOUGH FOR GRID-CONNECTED APPLICATION, LARGE WIND TURBINES, CENTRAL RECEIVER, PARABOLIC DISH AND SALT POND SOLAR THERMAL SYSTEMS, HIGHER-YIELD BIOMASS SPECIES AND CONVERSION SYSTEMS, AND OCEAN THERMAL ENERGY CONVERSION TECHNOLOGIES. THE PROGRESS WE WILL MAKE IN THESE AREAS, SOME OF THE MOST PROMISING IN THE WHOLE RENEWABLES SECTOR, IS DIRECTLY RELATED TO CONTINUED R & D ASSISTANCE FROM THE FEDERAL GOVERNMENT.

MR. CHAIRMAN, THE RENEWABLE ENERGY PROGRAM BUDGET WAS REDUCED BY OVER ONE HALF DURING DELIBERATION ON THE FISCAL YEAR 1982 BUDGET. THE ADMINISTRATION HAS PROPOSED REDUCING IT FURTHER -- BY ALMOST THREE FOURTHS -- IN FY '83. THIS WOULD MEAN A REDUCTION IN THE FEDERAL COMMITMENT TO RENEWABLE ENERGY R & D OF MORE THAT $500 MILLION -- ALMOST 90 PER CENT -- IN LITTLE

MORE THAN A YEAR'S TIME. IT IS UNREALISTIC AT BEST TO THINK THAT THE INDUSTRIES INVOLVED IN THIS AREA CAN ASSUME THAT KIND OF FINANCIAL BURDEN, PARTICULARLY IN TODAY'S TIGHT CAPITAL MARKETS, AND FILL IN WHERE FEDERAL SUPPORT IS WITHDRAWN.

THIS IS NOT TO SAY THAT RENEWABLE ENERGY INTERESTS EXPECT A CONTINUATION OF THE KIND OF BUDGET LEVELS AUTHORIZED AND APPROPRIATED BY CONGRESS FOR RESEARCH AND DEVELOPMENT IN RECENT YEARS. WE HAVE BEEN WILLING TO ABSORB OUR SHARE OF THE BUDGET REDUCTIONS IMPOSED ON FEDERAL EXPENDITURES OVERALL AND ON ENERGY SUPPLY R & D IN PARTICULAR. LAST YEAR WE PROPOSED A BUDGET ROUGHLY TWO THIRDS OF THE AMOUNT ORIGINALLY PROPOSED FOR 1982 BY THE CARTER ADMINISTRATION. THIS YEAR, WE ARE ENCOURAGED BY THIS COMMITTEE'S SUPPORT FOR CONTINUATION OF ENERGY DEVELOPMENT PROGRAMS AT LEVELS COMPARABLE TO THOSE EVENTUALLY AGREED ON FOR FY 1982. WE FEEL THAT THIS LEVEL OF FUNDING IS NEEDED IN FY 1983 TO CONTINUE ESSENTIAL WORK ON RENEWABLE TECHNOLOGIES STILL UNDER DEVELOPMENT AND TO ENSURE THAT AN ADEQUATE RETURN IS GAINED ON THE SUBSTANTIAL FEDERAL INVESTMENT IN RENEWABLE ENERGY DEVELOPMENT MADE SO FAR.

A PERSPECTIVE THAT IS USEFUL IN VIEWING FEDERAL EXPENDITURES FOR RENEWABLE ENERGY R & D AS GOOD INVESTMENTS IS THE INTERNATIONAL ONE. FEDERAL SUPPORT THAT GENUINELY ACCELERATES

THE MARKETABILITY OF U. S. RENEWABLE ENERGY TECHNOLOGIES CAN BRING REAL RETURNS ON THE INTERNATIONAL ENERGY MARKET.

GENERALLY SPEAKING, THE U. S. HOLDS A TECHNOLOGICAL EDGE IN RENEWABLE ENERGY. FEDERALLY-SUPPORTED RESEARCH HAS BROUGHT MOST OF THESE TECHNOLOGIES TO THE POINTS WHERE THEY ARE TODAY. THE U. S. ALSO CURRENTLY COMMANDS THE WORLD RENEWABLES MARKET, WHICH IS BOTH LARGER AND MORE ACTIVE RIGHT NOW THAT THE U. S. ONE.THESE FACTORS MAY CHANGE, HOWEVER, PARTICULARLY IF THE U. S. GOVERNMENT DRAMATICALLY REDUCES ITS SUPPORT FOR FURTHER DEVELOPMENT OF RENEWABLE TECHNOLOGIES.

A NUMBER OF OTHER INDUSTRIALIZED NATIONS -- MOST NOTABLY FRANCE, GERMANY AND JAPAN -- ARE SUBSTANTIALLY INCREASING THEIR GOVERNMENT SPENDING ON RENEWABLE ENERGY DEVELOPMENT. FRANCE, FOR EXAMPLE, PLANS TO SPEND $3.8 BILLION OVER A TEN YEAR PERIOD TO DEVELOP RENEWABLE ENERGY SYSTEMS AND TO MARKET THEM WORLDWIDE. JAPAN OPENLY EYES THE U. S. AS A MARKET FOR ITS RAPIDLY EXPANDING PHOTOVOLTAICS INDUSTRY. IT IS SIGNIFICANT THAT THE GROWTH OF THE JAPANESE PV INDUSTRY AND ITS AGGRESSIVE PURSUIT OF INTERNATIONAL MARKETS IS DIRECTLY RELATED TO JAPANESE GOVERNMENT R & D AND MARKETING SUPPORT.

IT WOULD BE IRONIC -- BUT IT CERTAINLY IS CONCEIVABLE --

TO SEE FOREIGN COMPANIES COMPETING IN AND DOMINATING THE U. S. MARKET WITH TECHNOLOGIES LARGELY DEVELOPED IN THIS COUNTRY. FOR THE SAKE OF OUR INTERNATIONAL BALANCE OF TRADE ALONE, IT WOULD CERTAINLY SEEM WISE AT THIS POINT FOR THE U. S. TO FOLLOW THROUGH ON ITS PREVIOUS INVESTMENTS AND TO BRING THESE TECHNOLOGY DEVELOPMENT PROCESSES THROUGH TO THEIR APPROPRIATE AND PURPOSEFUL CONCLUSIONS. THAT WILL, AT A MINIMUM, PROTECT OUR DOMESTIC MARKET FROM FOREIGN EXPLOITATION. IT WILL ALSO HELP US MAINTAIN OUR CURRENT LEADERSHIP IN THE WORLD MARKET.

THERE IS MORE THAT WE SHOULD DO, HOWEVER, TO REALLY TAKE ADVANTAGE OF THE WORLD MARKET FOR RENEWABLE ENERGY SYSTEMS. WE SHOULD CREATE A STRUCTURE WITHIN WHICH OUR INDUSTRY CAN OPERATE AND THAT CAN PROVIDE IT WITH LOGISTICAL, TECHNICAL AND FINANCIAL ASSISTANCE IN ADDRESSING FOREIGN MARKETS. THIS IS ESSENTIALLY WHAT OTHER COUNTRIES DO AS A MATTER OF COURSE, AND IT IS QUITE POSSIBLY WHAT WE WILL HAVE TO DO TO EFFECTIVELY COMPETE WITH THEM. WHETHER IT BE THROUGH THE WORLD BANK, OR AN INTERNATIONAL MARKET DEVELOPMENT PROGRAM LIKE THE VERY SUCCESSFUL ONE CONDUCTED IN RENEWABLE ENERGY BY THE ENERGY AND COMMERCE DEPARTMENTS, OR THROUGH A U. S. EXPORT TRADING COMPANY AS HAS BEEN PROPOSED AND ENDORSED BY THE SENATE, THE U. S. MUST DEVOTE SOME EFFORT AND RESOURCES IF IT IS TO REMAIN A LEADING SUPPLIER OF RENEWABLE ENERGY SYSTEMS WORLDWIDE.

THE FEDERAL COMPONENT TO THE OVERALL U. S. EFFORT IN RENEWABLE ENERGY IS ESSENTIAL IN ANOTHER SIGNIFICANT WAY. IT IS THE ONLY REAL MEANS OF MAINTAINING THE PARTICIPATION OF SMALL, INNOVATIVE BUSINESSES IN RENEWABLE ENERGY DEVELOPMENT. THESE FIRMS OFTEN CANNOT ATTRACT SUFFICIENT AMOUNTS OF CAPITAL TO UNDERWRITE THEIR WORK, YET THEY ARE THE KINDS OF COMPANIES THAT CONTRIBUTE TO TECHNOLOGY DEVELOPMENT TO AN EXTENT FAR BEYOND THEIR NUMBERS OR SIZE. A GAO REPORT RELEASED IN DECEMBER OF LAST YEAR CITES A NUMBER OF OTHER STUDIES THAT HAVE FOUND SMALL BUSINESSES TO BE FAR MORE INNOVATIVE THAN LARGE BUSINESSES OR CORPORATE RESEARCH LABORATORIES. IN ANY TECHNICAL FIELD, BUT PREHAPS ESPECIALLY IN ONE AS DIVERSE AS RENEWABLE ENERGY, INNOVATIVE SMALL BUSINESS PARTICIPATION IS A REAL ADVANTAGE. TO THE EXTENT THAT THE FEDERAL PROGRAM PROVIDES ESSENTIAL INCOME OPPORTUNITY FOR THESE SMALL RESEARCH FIRMS, FUNDING FOR THAT PROGRAM IS A GOOD INVESTMENT.

ASIDE FROM THE DRASTICALLY REDUCED FUNDING LEVELS PROPOSED BY THE ADMINISTRATION FOR THE RENEWABLE ENERGY PROGRAM, WE ARE SERIOUSLY CONCERNED WITH THE REDIRECTION OF IT EXCLUSIVELY TOWARD LONG RANGE RESEARCH AND AWAY FROM NEARER-TERM ACTIVITIES THAT HELP THE PRIVATE SECTOR ADOPT AND MAKE FULL USE OF FEDERAL RESEARCH RESULTS. THIS KIND OF ACTIVITY REPRESENTS, IN LARGE PART, THE FINAL STAGES OF SUPPORT THAT ARE SO IMPORTANT TO THE

REALIZATION OF A FULL RETURN ON THE GOVERNMENT'S R & D INVESTMENT. THE NEED FOR IT, HOWEVER, IS NOT NECESSARILY SO LONG STANDING AS TO REPRESENT A SERIOUS BUDGETARY MORTGAGE. IN FACT, WE HAVE BEEN WORKING TO IDENTIFY CONSTITUENCIES FOR SOME PROGRAM ACTIVITIES THAT CAN SUSTAIN THEM IN THE ABSENCE OF FEDERAL SUPPORT.

A GOOD EXAMPLE OF THIS IS IN THE AREA OF RENEWABLE ENERGY INFORMATION FOR CONSUMERS AND BUSINESSES. THE GOVERNMENT HAS BEEN PROVIDING A VALUABLE SERVICE IN AN EASILY-ACCESSIBLE SOURCE OF INFORMATION ON RESIDENTIAL SOLAR SYSTEMS AND THEIR SUPPLIERS. THE NATIONAL SOLAR HEATING AND COOLING INFORMATION SERVICE (NSHCIC) HAS HAD ITS MANDATE EXPANDED TO COVER ALL RENEWABLE ENERGY AND ENERGY CONSERVATION TECHNOLOGIES. IT IS NOW THE CONSERVATION AND RENEWABLE ENERGY INQUIRY AND REFERRAL SERVICE (CARIERS). NO FUNDING HAS BEEN PROPOSED, HOWEVER, FOR ITS OPERATION IN 1983. THE SOLAR LOBBY STRONGLY SUPPORTS THE CONTINUED FUNDING OF CARIERS. HOWEVER, AT THE SAME TIME WE ARE STUDYING THE POSSIBILITY THAT THIS SERVICE COULD BE COMBINED WITH OTHER IMPORTANT TRADE INFORMATION SERVICES IN A SELF-SUSTAINING PROGRAM. THE GOAL IS TO MAINTAIN AN IMPORTANT MARKET SERVICE, BUT TO SEEK WAYS TO HELP THE PRIVATE SECTOR ASSUME RESPONSIBILITY FOR ITS LONG-TERM OPERATIONS.

IN ANOTHER AREA, THE SOLAR LOBBY AND A NUMBER OF ORGANIZATIONS REPRESENTING INDUSTRY AS WELL AS USER PERSPECTIVES ON THE BUILDINGS SECTOR -- AND THESE INCLUDE THE SOLAR ENERGY INDUSTRIES ASSOCIATION AND THE BRICK INSTITUTE OF AMERICA -- HAVE COLLABORATED IN THE DEVELOPMENT OF A PROPOSAL FOR AN INTEGRATED RESEARCH PROGRAM ON ENERGY USE IN BUILDINGS. BY COORDINATING MORE THOROUGHLY THE RESEARCH EFFORTS IN ACTIVE AND PASSIVE SOLAR AND IN BUILDING AND COMMUNITY SYSTEM ENERGY CONSERVATION, IT IS HOPED THAT MORE EFFICIENT APPROACHES TO MEETING THE VARIOUS ENERGY NEEDS OF BUILDINGS AND THEIR OCCUPANTS CAN BE IDENTIFIED. THE BUILDING INDUSTRY, LIKE MUCH OF THE RENEWABLE ENERGY INDUSTRY, IS COMPOSED LARGELY OF SMALL AND INTERMEDIATE-SIZED COMPANIES. THUS A CENTRAL PROGRAM AT THE FEDERAL LEVEL HAS TREMENDOUS VALUE AS A MEANS OF FOCUSING INDUSTRY EFFORTS AND OF MAXIMIZING THE SPREAD OF RESEARCH RESULTS.

ESSENTIALLY, MR. CHAIRMAN, WE ARE SUGGESTING THAT CONTINUED EXPENDITURES IN SOME AREAS AND ADMINISTRATIVE IMPROVEMENTS IN OTHERS CAN, AT THIS CRITICAL POINT IN THE DEVELOPMENT OF RENEWABLE ENERGY TECHNOLOGIES, ENHANCE THE RETURN ON THE INVESTMENT THE NATION HAS MADE IN THIS AREA IN RECENT YEARS. FOR THAT REASON, WE FEEL VERY STRONGLY THAT ANY SUBSTANTIAL REDUCTION IN 1983 BELOW THE LEVEL APPROPRIATED IN FY 1982 FOR THE RENEWABLE ENERGY PROGRAM WOULD SERIOUSLY DIMINISH THE VALUE OF YEARS'

WORTH OF WORK. WE ARE ENCOURAGED BY THE SUPPORT ON THIS COMMITTEE FOR A CONTINUATION OF 1982 BUDGET LEVELS FOR ENERGY R & D IN 1983, AND WE ARE PREPARED TO ASSIST THE COMMITTEE IN WHATEVER WAY POSSIBLE IN ITS PURSUIT OF THAT OBJECTIVE.

THE SOLAR LOBBY IS CURRENTLY WORKING WITH RENEWABLE ENERGY INDUSTRY GROUPS -- AGAIN, INCLUDING THE SOLAR ENERGY INDUSTRIES ASSOCIATION AND THE BRICK INSTITUTE OF AMERICA -- ON A DETAILED 1983 BUDGET PROPOSAL FOR THE DOE RENEWABLE ENERGY PROGRAM. I AM HOPEFUL THAT THIS PROPOSAL CAN BE FINISHED IN THE NEXT WEEK OR SO, AND THAT THE RECORD OF THIS HEARING MIGHT BE LEFT OPEN LONG ENOUGH FOR ITS SUBMISSION.

THANK YOU AGAIN, MR. CHAIRMAN, FOR PERMITTING ME TO SHARE WITH YOU AND THE OTHER MEMBERS OF THE SUBCOMMITTEE THE SOLAR LOBBY'S VIEWS ON THIS IMPORTANT AREA OF FEDERAL ACTIVITY.

THE PUBLIC SPEAKS ON NUCLEAR ENERGY AND ENERGY CONSERVATION

Marvin E. Olsen, Eugene A. Rosa, and Don A. Dillman

Department of Sociology
Washington State University
Pullman, Washington 99164

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Facts do not cease to exist because they are ignored.
-- Aldous Huxley

The Great National Energy Policy Debate

A fundamental debate over national energy policy is currently being waged in the United States among scientists, engineers, economists, energy company executives, utility managers, public officials, and legislators. The eventual outcome of this debate will shape the nation's energy future for decades to come, direct the expenditure of hundreds of billions of dollars, influence the basic structure of national politics, and affect many realms of our social life.

Largely neglected in this energy policy debate, however, is the American public. The debate participants have given several justifications for ignoring the public: people are uninformed about this topic, the issue is too technical for lay people to understand, the public is irrational in its approach to risk assessment, most people aren't interested in the issue, or public interests are adequately represented by the various debate participants. Regardless of the validity of any of those claims, the simple fact is that the public is being largely excluded from the most important national policy debate confronting the United States in the closing decades of the twentieth century.

Public opinion establishes the boundaries within which this debate must be resolved and the resulting decisions implemented. To ignore public opinion on such a critical issue as national energy policy is to invite disaster in both policy formation and program development. This paper presents an overview of current public opinion regarding our great national energy policy debate and identifies several public stands on critical issues within this arena. It thus seeks to broaden the perspectives of the debate participants and to serve as a spokesperson for the public in the debate. In short, we challenge the debate participants to give serious attention to the policy preferences of the American public concerning national energy policy.

In its most general form, the energy policy debate revolves around the question: Should the United States meet its future energy needs primarily through increased energy production or through decreased energy demand? Until recently, we have equated energy consumption with economic growth and social well being, and assumed that energy companies and utilities had a responsibility to meet energy demand no matter how fast or high it grew. Since 1973, however, we have begun to realize that we waste huge amounts of energy in this country, that rising energy consumption is not necessary for economic growth and social well being, and that conservation is the most accessible and cheapest source of energy in the immediate future.

Although increased energy production could be achieved by switching from fossil fuels to several other alternative energy sources, most spokespersons for this policy position advocate increased development of nuclear energy. In contrast, proponents of reducing energy demand favor conservation efforts to use energy more efficiently and wisely. Hence the focus of the basic production-reduction debate often centers on the more specific controversy of nuclear energy versus energy conservation. That controversy is our principal concern here.

In 1977, President Carter announced that conservation would be the cornerstone of his proposed national energy policy, and this stand was imbedded in the National Energy Act of 1978. In 1981, President Reagan's National Energy Policy Plan radically altered this position by assigning conservation almost entirely to the private sector and stating that: "The Administration is committed to reversing past Federal Government excesses and to provide a more favorable climate for efficient energy production, thus allowing nuclear power to compete fairly in the marketplace with other potential sources of energy supply."[1] Even clearer are the proposed budget figures for FY 1983: $22 million for conservation and $870 million for nuclear fission.

The presidents have clearly stated their stands on the nuclear-conservation controversy. But where does the American public stand on this issue? Two questions are crucial here: (1) How strongly does the public support each of these two energy policies -- developing nuclear energy and promoting energy conservation -- as a solution to our future energy needs? (2) To what extent is the public polarized on this controversy so that it favors one policy but not the other, as opposed to taking a more ambiguous stance? We address each of these questions in turn.

By providing answers to these questions we are doing precisely what is called for in the 1981 National Energy Policy Plan: "The best guarantee of maintaining a wholesome balance among competing interests in regard to energy lies in allowing the American public themselves to make free and fully informed choices."

Public Support for Nuclear Energy and Energy Conservation

To answer the first question of how strongly the public supports the two policy options of developing nuclear energy and promoting energy conservation, we draw on data gathered by several surveys and polls conducted during the past two years.

When asked in public opinion polls whether they favor or oppose the construction of more nuclear plants, the public has recently divided almost evenly on this questions, with about 45% on each side. However, when people are given the three-way choice of (a) building more nuclear plants, (b) operating the ones now in existence and under construction but not starting any more plants, or (c) closing down all nuclear power plants, only about 30% favor increased construction, compared to about 40% who choose the second alternative and about 15% who support the third option. And when that third option is qualified by asking "Should all nuclear power plants be closed down until questions about safety are answered?" the level of agreement rises to about 45%.[2]

Those questions were limited to support for nuclear energy, and did not ask about conservation. In November, 1981, a national poll sponsored by NBC News and the Associated Press directly asked people: "Do you think the future energy needs of the United States would better be served by expanding nuclear power, or would they be better served by more conservation and expansion of other energy sources? Since the conservation option in this question also includes developing alternative energy sources, it is not surprising that 63% of the respondents favored that choice, compared to only 18% for nuclear power (the remainder favored both options or were unsure).[3]

A more meaningful way of probing people's choices among competing energy policies is to list a number of alternative sources of energy for the future and ask the respondents to indicate which ones they most and least prefer. This type of question was asked in two national surveys conducted in 1980 by Resources for the Future for the Council on Environmental Quality[4] and by the Solar Energy Research Institute.[5] Both studies listed the alternatives of solar energy, nuclear energy, energy conservation, oil and natural gas, coal, synfuels, and hydropower. The results from the two studies were almost identical. Solar energy was by far the first choice as an energy source for the future, while conservation ranked second. Ranking somewhat lower were synfuels, coal, oil and natural gas, and hydropower. Nuclear energy ranked last in both surveys. Conversely, nuclear power was rejected by 33% of the respondents in one study and 45% in the other. No other energy source received more than 15% rejection in either study.

A similar but slightly different question was included in a survey we conducted in 1981 in ten Western states, plus Pennsylvania as a point of comparison, with nearly 10,000 completed questionnaires.[6] The same energy alternatives (except for hydropower) were listed in this survey, but instead of giving only their strongest and weakest preferences, respondents indicated whether they favored or opposed further development of each energy surce. Solar energy again ranked first, drawing support from over 90% of the respondents. Three different forms of conservation included in this study received varying levels of public support: conservation in the home was approved by 75%, in business and industry by 65%, and in personal transportation by 55%. And in line with the two national studies, nuclear energy received the least support, being approved by only 4[illegible] of the people in the Western states and 34% in Pennsylvania.

Finally, it is significant that the rankings obtained in all three studies are relatively consistent across all ages, races, socioeconomic levels, and residential locations. The only significant variation is that women support nuclear energy considerably less than do men.

The conclusion to be drawn from these recent studies is unequivocal. A substantial majority of the American public opposes further development of nuclear power plants. Conversely, a large majority of the public supports efforts to promote greater energy conservation, especially in the residential, commercial, and industrial sectors. Even conservation in personal transportation, which several studies have found to be the least popular form of conservation with the American public, is supported by more than half the people. And almost everyone favors increased use of solar power.

The Reagan Administration's determined pro-nuclear policy is flying the the face of very strong and widespread public opposition to nuclear energy and public support for energy conservation and solar energy. The public appears to have made its choice among competing national energy policies, as called for by the Administration's National Energy Policy Plan.

Public Polarization on the Nuclear-Conservation Issue

The research findings presented thus far suggest that must of the public is fairly polarized on the question of nuclear energy versus conservation -- as are many energy experts and policy makers. Polarized debates often ignore alternative or compromise positions, however, which can prove critical in achieving a final resolution of the issue. After examing the opposing arguments for nuclear energy versus energy conservation, a recent policy study concluded that "The truth probably lies somewhere between these extreme views...."[7]

To investigate the extent to which the American public is actually polarized on the nuclear-conservation controversy, we turn to the results of our 1981 Western Region survey. (For ease of presentation, data from Pennsylvania are omitted here, but they are very similar to the data for the Western Region. In addition, the results from each Western state are virtually identical to those for the region as a whole.)

An initial indication that the public is not too highly polarized is seen in the responses to this broad question: "One way to meet our future energy needs is to cut back on energy use. Another way is to increase energy production. Which one of these choices do you feel our country should make in order to meet our future energy needs?" Energy production was chosen by 24% of the respondents and energy cut-backs by 8%, while 68% wanted to depend equally on both options.

We then used people's evaluations of alternative energy surces (from the question mentioned previously) to divide them into four distinct policy position on the nuclear-conservation issue: (1) favor nuclear energy and oppose conservation as a national energy policy; (2) favor conservation and oppose nuclear energy; (3) favor both nuclear energy and energy conservation; and (4) oppose both nuclear energy and conservation.

In the Western Region, approximately 29% of the respondents are in the nuclear only category, 31% are in the conservation only category, 19% favor both choices, and 23% support neither choice. Allowing for a margin of sampling error around these figures, we can say in general that about 30% of the population in this region falls into each of the two single-choice categories. Hence about 60% of the public is relatively polarized by being committed to one side or the other of the nuclear-conservation constroversy. And the two sides of this conflict are quite evenly balanced. At the same time, approximately 40% of the public is not polarized, with about half of these people favoring both nuclear energy and energy conservation and half favoring neither choice as a national energy policy.

The members of these four policy positions differ somewhat, although not markedly, on several sociodemographic characteristics. Very briefly, nuclear only supporters are somewhat more likely to be males with relatively high incomes who are homeowners. Conservation only supporters are somewhat more likely to be under age 35, college graduates, and hold high-status occupations (although their incomes are only average). Persons who support both options are rather typical of the total population, while many of those who reject both choices have slightly below-average socioeconomic statuses.

More interesting is the finding that people who see the U.S. energy situation as very serious are more likely than others to support conservation as a national energy policy. This is true regardless of whether or not they also favor development of nuclear energy. The proportion of respondents saying "very serious" is about 55% among those who favor conservation only and among those who favor both conservation and nuclear energy. The corresponding figure is about 30% among persons who favor nuclear energy only or neither option.

As a means of meeting our future energy needs, development of solar energy is supported by over 90% of the people in all four policy positions on the nuclear-conservation issue. There is apparently no serious opposition to solar energy among the American public. There is considerable disagreement over coal and oil shale as alternative energy sources, however. About 80% of the people who favor nuclear energy but not conservation also approve of developing coal and oil shale, compared to only about 50% of those who favor conservation but not nuclear energy.

Persons in the other two policy categories fall between these extremes. About 70% of those who favor both nuclear energy and conservation approve of these other energy sources, while about 60% of those who favor neither nuclear energy nor conservation do approve of developing coal and oil shale.

The principal conclusion to be drawn from this analysis is that the controversy between development of nuclear energy and increased energy conservation as national policies is considerably more complicated than is often assumed. About 60% of the public has taken a clear stand on one side or the other of this conflict, but the other 40% either favors both energy options or neither of them. At the same time, there is almost no controversy over the proposal to develop solar energy, but support or opposition in regard to coal and synfuels as alternative energy sources does tend to parallel the nuclear-conservation debate. Further compounding this situation is the fact that people who view the national energy situation as very serious are also quite likely to favor energy conservation, regardless of their views toward nuclear energy.

Public Acceptance of Energy Conservation

Although only about half of the American public favors energy conservation as a basic national policy (with or without nuclear energy), how extensively does the other half of the population accept the goal of reducing energy consumption? The fact that total energy consumption in the United States fell by 3.7% in 1980 -- a large proportion of which was apparently due to conservation efforts[7] -- suggests that conservation may be more widely supported in practice than in theory.

To explore this possibility, we asked respondents in our Western Region survey whether or not they approved of several fairly specific and stringent conservation program proposals. Over 80% of the public approved of (1) requiring manufacturers to make energy efficient appliances, (2) providing larger tax credits for home conservation and solar improvements, and (3) changing building codes and mortgage requirements to encourage conservation. Over 50% approved of (4) keeping the 55 MPH speed limit, and (5) requiring utilities to raise their rates with increased consumption. At the same time, other proposals received considerably less than majority support, including (6) placing higher taxes on gasoline, (7) requiring all homes to pass an energy audit, and (8) discouraging the building of new homes away from towns and cities to lessen travel distances. Of critical importance, however, is the fact that these levels of public support were roughly the same across all four positions on the nuclear-conservation controversy. People who favor conservation as a national policy (with or without nuclear energy) tend to be somwhat more approving of all these conservation programs than are people in the other two categories, but those differences are typically less than 10%. The only program proposal in our questionnaire that was accepted by a majority of those who favor conservation and rejected by most other respondents was requiring home thermostats to be no higher than 65^0 in winter.

When we move from acceptance of conservation programs to actually taking conservation actions in one's household, an even more interesting finding emerges. Persons who favor nuclear energy and reject energy conservation as a national policy are more likely than other people to have taken such household conservation actions as caulking and weatherstripping, installing additional insulation, installing double-pane windows and storm doors, and turning down the temperature of the hot water heater. In addition, persons who favor both nuclear energy and conservation are more likely than those who favor only conservation to have taken all these actions. The only conservation actions on our list that were most frequently taken by persons who favor conservation and reject nuclear energy as national policies were setting the thermostat at 65^0 or lower and closing off unused rooms. None of these differences can be attributed to other factors such as age, education, or income.

These findings concerning support for energy conservation programs and practices suggest to us that the goal of reducing energy consumption is quite strongly supported by the American public in programatic and action terms. This is true regardless of whether or not people favor making energy conservation a national energy policy, and whether or not they support further development of nuclear energy. As a result, the basic debate over increased energy production versus decreased consumption is even more complicated than is commonly believed.

Conclusions and Policy Implication

The major conclusions to be drawn from this examination of public opinion on current energy issues are that:

1. A substantial majority of the U.S. public prefers to develop all other energy sources -- especially solar energy -- before going any further with nuclear power plants. Thus public opinion clearly opposes the Reagan Administration's National Energy Policy favoring extensive federal support for developing nuclear energy.

2. About 60% of the public is polarized on the controversy over nuclear energy versus energy conservation as a national energy policy, with the two sides of this issue presently receiving equal support. At the same time, about one-fifth of the public wants to pursue both energy options and another one-fifth opposes both.

3. The underlying issue of energy production versus reduced consumption cannot be reduced to a simple dichotomous choice. Almost everyone favors more use of solar energy, regardless of their position on the nuclear-conservation controversy, and large majorities of the people also favor greater development of other energy sources such as coal and synfuels.

4. At the same time, support for energy conservation is also very strong among the American public, regardless of one's position on the nuclear energy issue. Although only about half the public thinks that energy conservation

should be a national energy policy, large majorities of the people support a variety of rather stringent conservation program proposals and are taking conservation actions in their homes.

In general, the American public apparently wants to increase energy production through extensive development of solar energy and at least some expansion of other energy sources such as coal and synfuels, but it does not want any further construction of nuclear power plants. At the same time, the public also takes energy conservation quite seriously, wants the federal government to establish a variety of effective energy conservation programs, and is taking household conservation actions to reduce energy consumption. In brief, a significant majority of the public is saying: "Let's pursue both energy production and conservation, but not nuclear energy."

This message has an obvious implication for the Reagan Administration's energy policy. Paraphrasing Abraham Lincoln, this implication is that: Government can oppose the wishes of some of the people some of the time, but it cannot oppose the wishes of most of the people all of the time.

Footnotes

[1] U.S. Department of Energy, "The National Energy Policy Plan." Washington, D.C.: U.S. Government Printing Office, 1981.

[2] Rankin, William L., "Overview of National Attitudes Toward Nuclear Energy: A Longitudinal Analysis." Presented at the 1982 annual meeting of the American Association for the Advancement of Science.

[3] NBC News, "November National Poll." New York: NBC News Poll Results, 1981.

[4] Resources for the Future, "Public Opinion on Environmental Issues." Washington, D.C.: Council on Environmental Quality, 1980.

[5] Solar Energy Research Institute, "Report on Building a Sustainable Future." Washington, D.C.: U.S. Government Printing Office, 1981.

[6] Details of the methodology used in this study and the full results are available from the authors.

[7] Landsberg, Hans H. et al., Energy: The Next Twenty Years. Cambridge, Mass.: Ballinger Publishing Co., 1979.

[8] Hirst, Eric et al., "Energy Use from 1973 to 1980: The Role of Improved Energy Efficiency." Oak Ridge, Tenn.: Oak Ridge National Laboratory, 1981.

THE BUILDING ENERGY RESEARCH PROGRAM

AN INTEGRATED APPROACH TO FEDERAL RESEARCH ON BUILDING ENERGY USE

APRIL, 1982

Developed through the cooperative efforts of representatives of the following groups:

American Council for an Energy-Efficient Economy
American Institute of Architects
Brick Institute of America
Building Energy Design Tool Council
Building Owners and Managers Association International
Energy Conservation Coalition
Environmental Policy Institute
Federation of American Scientists
International Union of Bricklayers and Allied Craftsmen
National Association of Home Builders
National Association of Home Builders Research Foundation
National Home Improvement Council
Northeast Retail Lumbermen's Council
Passive Solar Industries Council
Solar Energy Industries Association
Solar Lobby

BUILDING ENERGY RESEARCH PROGRAM

SUMMARY

A number of groups, representing the buildings sector and public interest concerns, are proposing the establishment of a comprehensive and integrated Building Energy Research Program. This program would consolidate the three primary federal research and development efforts concerned with buildings-related energy technologies: the Buildings and Community Systems Energy Conservation Program and the Active and Passive Solar Heating and Cooling Programs. Combining these elements into one program will permit more efficient usage of the very limited federal funds available for building energy research. And, perhaps more importantly, it will facilitate the examination of buildings as dynamic, integrated energy systems.

A comprehensive building energy research program is essential, because buildings use over a third of the nation's energy. To date, a number of federal programs have helped the nation's building industries make progress in developing ways to reduce the consumption of energy in this sector. But these programs have been organized around individual technologies, rather than in a coordinated approach to improve the overall energy efficiency of buildings. Similarly, these programs have placed insufficient emphasis on meeting the technical and informational needs of the individuals, organizations and businesses that actually construct and use buildings.

Despite these problems, progress has been made. Expertise has been developed on how to audit residential buildings for the efficiency of their energy use. Active and passive solar technologies are evolving, which permit dramatic reductions in the use of conventional energy in buildings. New, more energy-efficient products have been successfully tested and introduced for commercial application. These steps have happened as a result of federally-sponsored research and development.

An examination of the buildings sector reveals why, in addition to its potential for energy savings, a federally-supported energy use research program is needed. The building industry is decentralized, predominantly made up of many small-to-medium-sized firms involved in building construction or in the distribution of systems and components that go into buildings. This makes it very difficult for the industry to undertake a comprehensive energy research program. Building users are likewise very diverse, including major public and private institutions, small businesses, and individual owners and renters of single family homes and apartments. A coordinated federal research program is essential to address this wide range of interests in a meaningful way and to continue the nation's progress toward real energy efficiency in buildings.

The proposed Building Energy Research Program is an *integrated* and *comprehensive* approach to energy research which meets the needs of both building owners and occupants to reduce energy comsumption and of the building industry to develop cost-effective approaches to reducing conventional energy use. Key aspects of the proposal are:

1. *Buildings should be treated as integrated and dynamic energy-using systems.* This approach recognizes that greater energy efficiency can be attained by appropriate coordination of various energy technologies and components within a building or between a building and a larger community-scale system or utility grid. This approach also departs from the more traditional consideration of energy conservation and active and passive solar as separate technologies.

2. *The Research program should be based upon the actual behavior of occupied buildings.* Once again, this represents a departure from the present programs, which mainly model the behavior of occupied buildings on computers rather than gathering empirical data on them.

3. *Residential and commercial buildings should be treated separately.* These buildings have different design and construction techniques, different types of energy systems, and different use patterns. Research should be structured to recognize these differences. Moreover, within each of these categories, existing buildings are treated separately from new buildings, once again because the techniques involved in retrofit applications are quite different from those in new construction. (It is important to note here that, although it is much easier to incorporate energy efficiency improvements into new buildings, the potential for overall energy savings is much greater through the upgrading of the stock of existing buildings.) Finally, multi-family buildings are recognized as a unique problem in both the residential and commercial categories.

4. *The research program should be oriented toward the specific needs of those who will apply the research results, namely homebuilders, architects, engineers, appliance and product manufacturers, retrofitters, building owners and occupants.* This has not been sufficiently true of the existing programs. To provide the proper orientation, this proposal calls for the direct involvement of the various members of the buildings sector in the planning and direction of the research program. This kind of partnership can ensure that the resources for energy research of the federal government and of industry will be used

most efficiently. It is important to note that considerable data on building energy technologies has been developed through the existing research programs. Even though we are suggesting the redirection of these programs, this data remains valuable, and deserves continued analysis and application within the proposed program.

5. The research program is balanced between near and long-term development work. It is unrealistic to consider that all the federal government needs to support in this area is basic research. The most promising research in the buildings sector -- with respect to energy savings -- lies with nearer-term developments. But the nature of the buildings industry, as was described, makes sole support for them by the industry as difficult as support for long-term research. As in the past, however, the industry will continue to lend its resources where appropriate to the application of technologies and strategies developed through the proposed program.

6. An ongoing component of the program should be research into the health and safety aspects of building energy systems. Recent problems with the indoor air quality of super-insulated structures suggest that attention should be given to potentially adverse side effects of new energy systems and design strategies. This kind of research is most appropriate for the federal government, which is charged with protecting the public health and safety.

The groups that have worked together to outline the Building Energy Research Program are convinced that a tightly-managed research effort can achieve substantial results if funded at a level roughly equal to the sum of funding levels authorized by Congress for fiscal year 1982 operations of the Active and Passive Solar Programs and the Buildings and Community Systems Program. We are convinced that such an investment is essential if the nation is to realize the enormous energy savings possible through improvement of the existing stock of buildings constructed when energy prices were low. We are also convinced of the importance of achieving even higher efficiencies in new buildings. While each of the representative groups might emphasize different specific needs within the research program, we all strongly support the concept of an integrated national program.

PROGRAM SCOPE

For each area of concern (residential, commercial, new and existing) the Buildings Energy Research Program should support the following types of work:

BASIC RESEARCH

Research on materials, components, and concepts fundamental to energy-efficient buildings.

APPLIED RESEARCH

Research Integration - integration of basic research elements into buildings and energy systems, and monitoring and evaluation of their performance in occupied buildings to produce an accurate understanding of energy-conserving strategies.

Prototype Development - development of systems, components and building techniques that can be used to implement energy-conserving strategies in cost-effective ways.

Institutional Research - analysis of institutional barriers that impede development and utilitzation of energy-efficient techniques in buildings, and assessment of ways to mitigate them.

TECHNOLOGY TRANSFER AND INFORMATION DISSEMINATION - packaging of program results (information on products, components, systems and innovative institutional approaches) in forms useful to the individuals, organizations and businesses that are involved in the design, construction, purchase and use of buildings (including demonstrations to prove the feasibility of innovative building products, techniques and institutional approaches).

RESEARCH NEEDS

The following is a list of important research needs in the residential and commercial buildings sector, for both new and existing stock. It is not comprehensive; it is intended to show some areas of priority.

RESIDENTIAL BUILDINGS - NEW

Basic Research

- Thermal load dynamics within buildings.
- New thermal storage and glazing materials.
- Building environmental quality (e.g. indoor air quality).
- Building materials and system controls.
- Research leading to high-efficiency appliances.
- Research leading to high-efficiency heating and cooling systems.

Applied Research

- Collection of data on thermal behavior of occupied buildings.
- Integration of solar systems with conventional heating and cooling systems.
- Collection of cost and performance data on integrated systems in various climatic regions.
- Assessment of the impact of energy efficient buildings on utility load management.
- New technologies for community-scale systems.
- Prototype development of thermal storage and building envelope materials and components, active and passive solar systems.
- Documentation and analysis of institutional decision making processes which affect the development and adoption of energy conserving strategies by end users (financial institutions, buildings owners, state and local governments).

Technology Transfer and Information Dissemination

- For homebuilders and construction trades (e.g. design innovations and construction techniques).
- For product manufactuers (e.g. performance data).
- For financial institutions (e.g. impact of energy systems and strategies on capital and operating costs).

- For building owners and occupants (e.g. operating costs).
- For local governments and utilities (e.g. innovative institutional approaches).

RESIDENTIAL BUILDINGS - EXISTING

Much of the necessary research is similar to that needed for new residential buildings. There is, however, an additional need to address the following:

Basic Research

- New retrofit materials.
- Cost-effective retrofit techniques to mitigate infiltration and conduction losses.

Applied Research

- Collection of cost and performance data on buildings before and after retrofit.
- Prototype development of packaged retrofit systems.
- Analysis of how relationships between building owners and renters affect energy decisions.

Technology Transfer and Information Dissemination

- For home owners, product and system distributors and remodelling contractors -- a much more dispersed set of industries than those involved with new buildings (e.g. retrofit manuals).
- Information on innovative delivery systems for local governments and utilities (e.g. one-stop-shop energy programs).

COMMERCIAL BUILDINGS - NEW

Basic Research

- New building shell and glazing materials (e.g. to reduce night heat loss).
- Building environmental quality (e.g. indoor air quality).
- Advanced lighting and HVAC systems and controls.
- Heat recovery systems.

Applied Research

- Analysis of energy dynamics and control strategies for complex, multi-zone buildings.
- Assessment of interrelationships between active and passive heating and cooling systems (and daylighting), and their integration with conventional systems, according to various building types and climatic regions.
- Collection of cost and performance data by building type and climatic region.
- Prototype development of HVAC systems - (e.g. for individual building zones), lighting systems and strategies, heat recovery systems, and glazing systems.
- Assessment of financial and institutional factors affecting energy decisions by building owners (including concerns of financiers and occupants).

Technology Transfer and Information Dissemination

- For architects, engineers and developers (e.g. design and analysis tools that accurately predict building performance).
- For financial institutions (e.g. impact of energy systems and strategies on capital and operating costs).
- For building owners and occupants (e.g. operating costs).
- For product manufacturers (e.g. performance data).
- For local governments and utilities (e.g. innovative institutional approaches).

COMMERCIAL BUILDINGS - EXISTING

Much of the necessary research is similar to that needed for new commercial buildings. There is, however, an additional need to address the following:

APPLIED RESEARCH

- Monitoring performance of buildings before and after retrofit.
- Improvement of operating efficiency of existing systems (e.g. through improved maintenance).

- Development of more efficient HVAC and lighting retrofit strategies, and of smaller, more efficient prototype replacement systems.

- Development of energy retrofit techniques that meet other rehabilitation requirements (e.g. for fire protection, structural integrity and building safety, among others).

- Analysis of how relationships between building owners and occupants affect energy decisions.

Technology Transfer and Information Dissemination

- For architects and engineers (e.g. cost and performance data on retrofit strategies).

- For product manufacturers (e.g. product performance data).

- For utilities, local governments and energy management companies (e.g. innovative institutional approaches).

THE RENEWABLE ENERGY ALTERNATIVE AS CRITICAL AS EVER

a program to continue development of promising renewable energy technologies

JUNE 1982

SOLAR LOBBY/SOLAR ENERGY INDUSTRIES ASSOCIATION

Solar Lobby
1001 Connecticut Avenue, NW, Suite 510
Washington, D.C. 20036
(202)466-6350

Solar Energy Industries Association
1001 Connecticut Avenue, NW, Suite 800
Washington, D.C. 20036
(202) 293-2981

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Introduction

From the mid-1970's until the beginning of the current Administration, Federal support for renewable energy took a variety of complementary forms. Authorized through a series of laws, renewable energy programs were directed toward estimating the potential for renewable energy applications, pursuing research on promising technologies, enhancing the manufacturing and marketing capability of the renewable energy industry, and bringing down the costs of systems to consumers.

This effort is beginning to bear fruit. The leading edge of renewable energy technology is succeeding in the marketplace, and even more promising applications are being developed. The Federal solar program has broadened and enhanced the total contribution that renewable energy can make to the United States' energy mix.

Since January of 1981, however, the scope of the Federal renewable energy program has been reduced. The Administration proposes to support only long-range, high-risk research activities. Commercialization efforts, consumer information programs, economic incentive programs, and technology demonstrations would all be abandoned on the grounds that the energy marketplace alone should govern the development of renewable energy. Unfortunately, the Administration overlooks the imperfections of the energy marketplace. In fact, by increasing support for competing energy industries, the Administration is further distorting the market against renewable energy.

Renewable energy supporters recognize the need for fiscal austerity, and have been willing to accept reductions in the Federal renewable energy development program. Yet we are convinced that the budget reductions imposed on renewable energy (53 percent in 1982; an additional 75 percent proposed for 1983) are excessive. They would abort the ongoing development of more cost-effective and productive renewable energy systems. The private sector simply cannot compensate for the abrupt removal of $500 million in development support.

"The Renewable Energy Alternative" outlines in detail a program to continue work on the most promising renewable energy technologies. It offers the collective advice of the leading industry and consumer elements of the renewable energy sector. It is not our ideal; it is an austere program, respectful of fiscal discipline. But we feel it is a necessary budget, to keep the United States in the forefront of renewable energy.

This budget, in its aggregate, is equal to the 1982 funding level. This in itself means a real reduction in program activities. We feel, as do substantial elements of the Senate and the House of Representatives, that reductions beyond those imposed in 1982 would seriously impair the nation's ongoing effort in renewable energy development.

DOE RENEWABLE ENERGY R&D PROGRAM
(budget authority in millions of dollars)

	1981 Appropriation	1982 Appropriation	1983 Admin. Request	1983 R.E. Alternative
Active Solar Heating and Cooling	43.7	11.5	0	14.0
Passive and Hybrid Solar Heating and Cooling	33.4	10.6	0	14.0
Photovoltaic Energy Systems	160.2	75.0	27.6	54.0
Solar Thermal Energy Systems	141.8	54.9	18.4	59.5
Biomass Energy Systems	46.5	20.5	6.75	24.0
Alcohol Fuels	20.8	10.0	3.0	10.0
Wind Energy Conversion Systems	85.8	34.4	5.6	44.4
Ocean Energy Systems	39.0	20.8	0	20.8
Renewable Energy Information	1.4	6.7	0	5.0
Renewable Energy International	12.0	4.0	9.5	11.5
Program Support	—	3.5	—	4.0
Solar Reserve Account	—	12.3	—	3.0
Program Direction (Administration)	6.8	4.0	2.146	4.0
Total DOE Renewable Energy R&D	591.4	268.2*	72.99	268.2

* — Takes into account $7.2 million reduction, part of $61 million assessed to Energy Supply R&D.

Active Solar Heating and Cooling

Active solar technologies are probably the most widely recognized solar applications. Flat plate collector systems for water heating have achieved substantial market acceptance in certain parts of the country. The Federal government has successfully accelerated the development of the active solar industry through its support for research and development, and through its various demonstration programs, which have resulted in the purchase of large numbers of systems.

Broader acceptance of active solar technologies will depend on a reduction in system costs, and on a fuller understanding of their economic viability in the context of integrated applications with passive solar techniques and more efficient conventional heating and cooling systems. In addition, consumer confidence in active solar will continue to rely on the development of consensus standards for performance and reliability. Because the active solar industry is still composed of relatively small companies that are not directly involved with other building technologies and cannot afford substantial research efforts of their own, the Federal government is the natural agent for pursuing this further development.

Potential active solar applications are not limited to water heating, however. Space heating and, perhaps more importantly, space cooling in warm-weather, high-insolation areas offer tremendous potential for the displacement of conventional, non-renewable energy sources. Realization of this potential will require a continued commitment by the Federal government to active solar technology development.

Further work in these space conditioning areas should be conducted in a more concerted fashion with passive solar heating and cooling techniques, and with efforts to develop more efficient conventional building heating, cooling and lighting systems. An integrated research program into building energy needs is recommended—and has been proposed separately to the Congress—that can take advantage of the complementary potential of all building energy systems. Like the active solar industry, the buildings sector as a whole is composed of small independent firms unable to conduct a centralized research program. Yet, considering that the buildings sector accounts for over one third of the nation's energy use, a concerted and focused effort toward greater building energy efficiency is vitally important.

ACTIVE SOLAR HEATING AND COOLING
PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Advanced Research and Development			7.25
Materials Research: for Glazings; High, Medium and Low-Temperature Absorber Coatings; Collector Enclosures; High-Temperature-Resistant Sealants and Insulation; Lower-Cost Reflectors		4.0	
Active Cooling Concepts: New and Emerging Concepts and Materials for Space Conditioning Applications (e.g. dessicant)		2.0	
Modelling of Integrated (active, passive and conventional) Systems to Assess Potential Load Factors		1.25	
Technology Development			6.0
Residential and Commercial Solar Heating and Cooling		2.25	
Monitoring and Data Collection from State-of-the-Art Systems (publicly and privately financed) to Compare and Document Performance, Reliability and Maintainability	0.75		
Integration With Passive Solar and Conventional Energy Systems in Residential Building Applications	1.5		
Residential and Commercial Cooling		2.25	
Continue Review of Existing Technologies (Rankine, Absorption) to Establish More Complete Understanding of System Economics			
Heat Pumps		0.5	
Review Heat Pump Development in Progress; Assess Potential for Solar to Complement			
Standards		0.6	
Development of Methodologies for Performance Measurement	0.5		
Safety Research on Refrigerant-Charged Systems	0.1		
Training		0.4	
Curriculum Development for Public and Private Training Programs			
Information Dissemination and Technology Transfer			0.75
Development of Research Results in Forms Useful to Active Solar Industry, Building Design Community and Building Construction Industry			
Total Active Solar Heating and Cooling			14.0

Passive and Hybrid Solar Heating and Cooling

As was cited in the preceding section on active solar, the buildings sector accounts for over one third of this nation's energy consumption. Thus, in order to continue to reduce reliance on conventional imported energy sources, it is appropriate and important for the Federal government to continue to support efforts to develop passive solar techniques for meeting building heating, cooling and lighting needs. Because the systems—both conventional and renewable—that address these needs are interrelated, we feel that it is important to study them in an integrated Building Energy Research Program—of which passive solar is a part—to pursue the greatest overall building energy efficiencies possible.

This represents the passive solar component to an integrated building energy research effort. We recognize that considerable progress has been made in passive solar through the Federal R&D effort, primarily in the residential sector. Simple passive solar designs are meeting success in the market for new housing. Yet further Federally-sponsored research is requred to develop more sophisticated passive solar concepts and designs for new structures, and to develop retrofit systems to address the energy needs of the tremendous stock of existing housing. The results of this work must be packaged with the needs of the building industry—for practical, buildable design tools—more in mind.

Passive solar is still underutilized in larger, commercial-type buildings. These are very complex structures, both in their thermal behavior patterns and in the energy delivery systems that they use. Yet they offer tremendous potential for reducing consumption of conventional energy. We feel strongly that the Federal Passive Solar Program, and building energy research effort overall, must devote more effort to the development of materials, systems and design tools appropriate to commercial building applications, that the design community can apply directly in the passive use of solar energy.

The building industry is extremely diverse, composed of mostly small businesses involved in the supply of building materials, and in the actual design and construction of buildings. This kind of industry simply cannot—at this time, at least—conduct the kind of centralized research program necessary to address the tremendous need in the buildings sector to reduce consumption of conventional energy. Thus a continued Federal effort in this area is critically important.

PASSIVE AND HYBRID SOLAR HEATING AND COOLING

PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Research and Technology Development		4.5
Materials Research	1.05	
New Thermal Storage and Glazing Materials for Residential and Commercial Applications		
Experimental Testing	0.7	
New Thermal Storage, Glazing and Moveable Insulation Systems for Residential Applications		
Systems Simulation and Analysis	1.05	
Selection by Empirical Validation of One or Two Computer Design Tools for Residential and Commercial Applications		
Thermal Science Research	1.7	
Thermal Load Dynamics of Residential and Commercial Applications		

Systems Testing and Evaluation		8.1
Collection of Data on Thermal Behavior of Residential and Commercial Buildings	2.8	
Integration of Passive Solar Techniques with Conventional Building Energy Systems	2.8	
Collection of Cost and Performance Data on Integrated Residential and Commercial Systems in Various Climatic Regions	1.75	
Development of High-Efficiency Heating and Cooling Systems for New and Retrofit Residential Applications	0.75	
Information Dissemination and Technology Transfer		1.4
Development of Design Guidelines and Tools for Residential and Commercial Design and Construction Communities	1.4	
Total Passive and Hybrid Solar Heating and Cooling		14.0

Photovoltaic Energy Systems

Photovoltaics, "solar cells" that generate electricity directly when exposed to sunlight, are making progress commercially in remote-site, off-the-grid applications. U.S. photovoltaic manufacturers are thought to have shipped five megawatts worth of systems in 1981, primarily of the first generation single-crystal silicon variety. The progress that represents is due in large part to the substantial Federal R&D effort of the past few years. Yet the real potential of photovoltaics lies with the lower-cost and more efficient cells coming with the second and third generations of the technology. If these are to mature in a timely fashion, however, and if the photovoltaics industry is going to develop into a broad-based and deep one, the Federal R&D support must continue at a meaningful level. Just as importantly, further work must be done on the systems that collect, condition and distribute the electricity from the cells, before any of the cell technologies can be used in widely competitive commercial ways.

The photovoltaics market for U.S. producers is primarily an overseas one. They dominate that market now, but are beginning to receive very serious competition from other nations. Industries have developed overseas that use technologies largely developed in the United States. Some governments are now spending more per capita on photovoltaics R&D than the United States is, and are subsidizing the marketing of these systems worldwide. To meet this challenge, the U.S. must continue the development of superior technologies, and must be more aggressive in pursuing overseas markets. This latter activity has not been a traditional one for U.S business or government. But both must take an active interest in it if this country is going to hold on to the valuable world photovoltaics market.

This budget recommendation represents a substantial reduction from the 1982 level. It recognizes the increased activity in the photovoltaics market and the increased commitment shown in the private sector for photovoltaics commercialization. But it continues program support in areas critical to maintaining the role of innovative and productive small businesses in photovoltaics development. This budget recognizes that one cell technology—single-crystal silicon—has evolved beyond a need for further Federal R&D support. But it maintains program support for the promising, less-developed cell technologies—amorphous silicon, polycrystalline thin film and concentrating cells—and for vital systems development work. In addition to providing for basic research support, which is fundamental to any R&D program, this budget recommends support in other areas uniquely suited to the Federal government at this time: worldwide solar resource assessment by satellite, the development of standards-setting methodologies and the development of a fundamental understanding of the performance of state-of-the-art photovoltaic systems.

The three laboratories that are most heavily involved in photovoltaics research—SERI, Sandia and Jet Propulsion—have performed successfully and continue to have appropriate roles in the program, even as its focus moves toward the second and third generations of the photovoltaics technology. Essentially, we are recommending the continuation of a balanced research and development program that will build on recent years' success and will help make photovoltaics a viable alternative for the generation of electricity. Ongoing work must be followed through to its natural conclusion, to make good on the investment by the government to date, and to keep good faith with members of the private sector who have made substantial financial commitments based on the existence of the Federal R&D program.

PHOTOVOLTAIC ENERGY SYSTEMS

PROPOSED FY 1983 BUDGET

(budget authority in millions of dollars)

Advanced Research and Development		25.0
Amorphous Silicon	10.0	
Polycrystalline Thin Film: Including Copper Indium Selenide and Zinc Phosphide	6.0	
Advanced Innovative Devices and Concentrators: Luminescents	4.0	
SERI In-House Program: Including a Technical Internship Program for Industry Researchers	5.0	
Technology Development		23.0
Advanced and Emerging Materials (emphasizing small business participation, with 50% or greater cost sharing for participating large industries	7.0	
Balance of Systems: Emphasis on Interface with Utility Grid	5.0	
Concentrating Devices	4.0	
Sacramento Municipal Utility District Project	7.0	
Systems Engineering and Standards		6.0
Performance Testing and Data Collection	2.0	
Standards Development	2.0	
Insolation—Data Aquisition	2.0	
Total Photovoltaic Energy Systems		54.0

Solar Thermal Energy Systems

Solar thermal systems, which concentrate solar energy for the production of electricity and industrial process heat, are evolving in a number of different forms that are at varying stages of development and commercial readiness. Parabolic trough concentrators are beginning to enter the commercial market. The central receiver (power tower) technology is being demonstrated near Barstow, California in a 10 megawatt system, and the small parabolic dish technology is being demonstrated in a cogeneration application (electricity and process heat generation) in Shennandoah, Georgia. Each of these demonstrations were made possible by the Federal Solar Thermal Program. The large parabolic dish technology is in the testing stage, and has achieved record efficiencies in the solar-powered generation of electricity. The hemispherical bowl concentrator has been tested at the prototype stage in a project at Crosbyton, Texas. However, at this time it does not show the potential for overall system efficiency needed to justify further Federal R&D support. Finally, the solar pond technology, that uses solar-heated brine for electricity generation, industrial process heat or water desalination, is in an earlier stage of development, but will soon be ready for testing in a prototype system.

Without question, the Federal R&D program is primarily responsible for the progress made to date in solar thermal energy. But it is just as true that further development of these and other solar thermal systems—and their real usefulness to the country—depends on continued support by the government. Industry will assume a greater support role as systems approach commercial readiness, and the Federal program's focus will shift toward technologies in earlier stages of development.

This budget recommendation, slightly less in real dollars than the amount appropriated for solar thermal energy in 1982, would complete Federal R&D support in a number of areas, such as development of the parabolic dish Brayton module, the Small Community Parabolic Dish Project and central receiver heliostat development. It would also continue funding for essential basic and applied research on the emerging technologies mentioned above, and on even newer concepts for the use of solar thermal energy.

SOLAR THERMAL ENERGY SYSTEMS

PROPOSED FY 1983 BUDGET

(budget authority in millions of dollars)

Research			10.3
Research Facilities Operation		4.8	
Central Receiver Test Facility	3.0		
Advanced Component Test Facility (GA Tech), White Sands Solar Furnace, Edwards AF Base, Test Bed Concentrators	1.0		
Parabolic Dish Systems: Edwards AF Base Test Bed Concentrators	0.8		
Parabolic Dish Applied Research; Ceramic Materials and Processes for High Temperature Receivers, Reflective Surfaces, Low Cost System Controls		2.5	
University Research: Innovative Concepts and Processes		1.0	
Sunfuels: Including Hydrogen Production		1.3	
Salt Ponds		0.5	
SERI Capital Equipment		0.2	
Technology Development			14.6
Brayton/Parabolic Dish System		2.5	
Receiver Development: Sodium and Salt-Cooled Concepts		3.3	
Steam Generator: Sodium and Salt-Driven		2.8	
Parabolic Dish: Design Competition for 2nd Generation Concentrators		2.0	
Parabolic Trough: Materials Development for More Efficient Absorbers, Reflectors, Etc.		1.0	
Parabolic Dish Hybrid Systems: Low Cost Natural Gas Substitute Fuels		1.0	
Technology Utilization: Coordination and Utilization of Applicable DOD Work in Heat Engine and Materials Development		1.0	
Heliostats: Adhesion of Reflective Surfaces		1.0	

Systems Applications		33.1
Solar I Operations: Data Collection to Address Performance, Cost & Durability Considerations	10.0	
Central Receiver Repowering Designs: Two Designs with Significant Cost Sharing by Industrial Participants	15.0	
Small Community Parabolic Dish Project	3.0	
Shennandoah: Project Completion	1.5	
Thermal Storage: Demonstration of Technical Feasibility	1.6	
Parabolic Trough Operations: Operation and Data Collection from DOE-funded Projects	2.0	
Program Direction and Planning		1.5
Total Solar Thermal Energy Systems		59.5

Biomass Energy Systems

Biomass currently contributes more energy production in the United States than any other renewable resource, primarily through the direct combustion of wood and wood by-products. Biomass energy systems, including those for making alcohol fuels, are the only renewable energy technologies that produce an actual fuel commodity. For the most part, the direct biomass combustion systems currently in the market are relatively simple conversions of conventional fossil-fuel boilers. But they represent the leading edge of a wide range of technologies for producing and using solid, liquid and gaseous fuels and oils from woody, herbaceous and aquatic plant species. And they have possible applications throughout this country and the world. The potential of biomass energy systems to help meet future energy needs has been well documented. What remains to be done, however, to realize this potential is to continue a broad-based research and development program into both the production of biomass and its conversion into useable energy.

The Federal government's role in biomass energy technology has been an important one. Because much of the work in biomass is conducted by companies not directly involved in energy production or by non-commercial research laboratories, and because much of the biomass resource base is associated with small farm and forest-oriented businesses, a comprehensive and integrative Federal program is needed. Over the past several years, the Federal government has sponsored development work across the wide range of biomass energy applications. Substantial progress has been made, for example, in low-BTU gasification, and those systems are beginning to enter the marketplace. More advanced and efficient woodstoves and fireplace inserts are commonplace in certain parts of the country. Municipal waste combustion systems are alleviating trash disposal problems and simultaneously producing energy.

A great deal more work is needed, however, to develop new plant species, harvesting techniques and conversion processes, before the biomass resource base is adequately developed. Research into plant genetics and cultivation techniques for more productive woody, herbaceous and aquatic species is a multi-year activity and must be carried through to its conclusion. Herbaceous (grassy) plants have been developed, for example, that now exceed the productivity of sugar cane, in terms of energy potential, by 33 percent. Continued research shows the promise of producing species that will double sugar cane's productivity. Even more striking examples of productivity improvement exist in the area of short-rotation woody crops, where Federally-sponsored research work has tripled productivity over three years' time, and promises comparable improvement in the future.

Research into biomass conversion processes has shown similar progress, increasing the process efficiency of medium-BTU gasification technologies by up to three fourths. Continuing research aimed at reducing or eliminating the need for costly oxygen in these processes promises to reduce overall system costs even further.

This budget proposal reflects a level of support that is sufficient to continue critical development work across the spectrum of biomass energy technologies. Such a broad-based program is essential if the nation is to make full and wise use of its immense biomass resource base.

BIOMASS ENERGY SYSTEMS

PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Biomass Production		12.3
Woody Biomass Feedstock Development	4.1	
Genetic Engineering: species screening, tissue culturing and hybridization techniques		
Analysis of Factors Affecting Growth Yields: geographic location, soil quality, fertilization, irrigation, silvicultural methods, frequency of coppicing		
Herbaceous Biomass Feedstock Development	2.0	
Genetic Engineering: species screening, hybridization for production from marginal lands		
Analysis of Cultivation Factors: geographic locations, soil quality, fertilization, etc.		
Environmental Assessment of Herbaceous Biomass Production		
Aquatic Biomass Feedstock Development	3.4	
Species Identification		
Genetic Engineering for Higher Yields		
Analysis of Production Conditions: water composition, flow velocity, nutrients, algal types, harvesting methods		
On-Shore Production Techniques: including comparison with off-shore applications		
Biological Production of Hydrogen	1.5	
Identification of Algae and Bacteria for Producing Hydrogen; Genetic Manipulation to Increase Yields		
Harvesting Systems: conceptual design and analysis	1.0	
Supporting Research: identification of higher yield species	0.3	
Biomass Conversion Technology		11.7
Gasification and Pyrolisis	6.0	
Low-BTU Gasification: examination of physical mechanisms, efficiencies and system emissions		
Medium-BTU Gasification: system efficiency improvement and cost reduction		
Pyrolisis: optimization of petroleum substitute yields		
Liquefaction	1.5	
Lab-Scale Research on Effects of Various Process Conditions, Catalysts, Carriers Liquids on the Production of Low-Oxygen Liquid Hydrocarbons		

Conceptual System Designs to Address Technical and Economic Feasibility as Functions of Scale and to Identify Further R & D Requirements		
Anaerobic Digestion of Cellulosic and Agricultural Residues	1.9	
Lab-Scale Experiments on Digester Designs, Pre-Treatments, Micro-Nutrients, Compaction and Other Operational Factors		
Identification and Genetic Engineering of Micro-Organisms to Produce Increased Biogas Yields		
Supporting Research	2.3	
Basic Studies of Biochemical and Thermochemical Conversion Phenomena		
Innovative Physical, Chemical, Enzymatic and Biological Methods for Increased Fuel Yields		
Environmental Impact (and Mitigation) Analysis		
Total Biomass Energy Systems		24.0

Alcohol Fuels

Alcohol fuels from renewable resources are the only high-grade, liquid fuel alternative marketed in the United States. By mid-1983, the domestic alcohol fuels industry will have on line 400 million gallons—or nearly 10 million barrels—of annual production capacity. Since almost one quarter of the United States' energy demand is in the transportation sector, the contribution of alcohol is important to offset imported petroleum, and for use as an octane enhancer to improve the quality of lower-grade gasolines. According to SERI, alcohol fuels could displace an equivalent of 2.6 million barrels of oil per day.

Today's first-generation ethanol facilities primarily use grains as feedstocks, and co-produce high protein foods in the process. However, there are other readily available resources from which we could produce alcohol that would allow greater yields of fuel, and would do so more efficiently. Cellulosic conversion is one technology that DOE has already invested in, which has the potential of revolutionizing alcohol production. The amount of cellulosic wastes available for conversion to alcohol is staggering; thus research already underway could yield important long-term results. At present, cellulosic conversion using acids and enzymes is in the laboratory stage. The processes require further research and testing.

Another key research area is in the use of membranes to remove water from alcohol in the distillation process, and to remove salt and other chemicals from the food by-products. The use of membranes in this way can reduce the energy requirements of the systems significantly, while their use in by-product preparation can result in much broader application in the production of animal and human foods and of fertilizer. Thus research in membrane technology offers excellent prospects for high payoffs.

In addition, this proposal would provide further funding for important end-use applications development. Alcohol has a wide range of potential uses, ranging from octane enhancement and fuel extension at the refinery level to uses as a fuel for peak-power electric generating units. Of particular promise is the use of alcohol as a neat (pure) fuel in the transportation sector. Dissociation technologies offer significant potential for improving efficiencies in these applications. And finally, increased research is needed—and provided for in this proposal—to advance the use of alcohols in diesel blends, through the use of micro-emulsion blending, turbocharge injection, and other methods.

ALCOHOL FUELS

PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Process Technology Development		6.0
Cellulosic Conversion	2.0	
Ligno-Cellulosic Conversion	1.5	
Alternative Feedstocks from Agricultural and Food Process Wastes	1.0	
Membrane Technology	1.5	
Integrated Systems Development		2.0
Integration with Greenhouses, Aerobic and Anaerobic Digesters and Non-Conventional Food Processing Wastes	1.25	
Enduse of CO_2 for By-Product Preservation or Grain Silo Protection	0.50	
Use of Solar Process Heat for Fermentation and By-Product Preparation	0.25	
End-Use Applications Development		2.0
Use of Ethanol and Ethanol-Oil Blends in Farm Diesels	1.0	
Prototype Testing of More Efficient Alcohol Burning Engines	1.0	
Total Alcohol Fuels		10.0

Wind Energy Conversion Systems

Wind power, like a number of other forms of solar-derived energy, involves applying modern engineering to a power source that is age-old and well known. The wind has been used as a source of mechanical energy for thousands of years, and the most sophisticated mechanical device of earlier days, the multi-bladed American farm wind mill, can still be seen on hundreds of thousands of farms throughout the Midwest.

Today, however, attention has turned to producing electrical power from the wind. While wind electric systems enjoyed a brief heyday in the 1920's and 1930's, before the advent of rural electrification, today's machines take advantage of advances in aerospace and materials technology to produce electricity at much lower costs—costs which are becoming competitive with those of power produced from conventional fuels.

DOE's Wind Energy Program has met or surpassed the cost goals set by its enabling legislation, the Wind Energy Research, Development and Demonstration Act. It has demonstrated that the potential exists for cost-competitive power from both large and small systems, and has stimulated the development of an industry which, although still miniscule, is rapidly growing. What is needed now is to finish the hardware development programs already in place, and to continue developing a research and technology base which can give industry the scientific information needed to keep improving and upgrading systems as they move into the marketplace.

This budget aims heavily toward the development of that "knowledge base." Like other parts of this alternative budget, it is constrained, in recognition of the severe funding difficulties with which Federal policymakers must contend. At the same time, however, unlike the Administration's proposed budget, it recognizes the imperative of continuing a meaningful level of support for a technology which promises to tap an abundant, inexpensive, nonpolluting and domestic source of energy in the years to come.

WIND ENERGY CONVERSION SYSTEMS
PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Systems and Operational Analysis		2.7
Wind Systems Economics and Market Analysis	0.4	
Applications Analysis	1.5	
Analysis of Institutional and Environmental Barriers: Consensus Standards	0.8	
Wind Characteristics		3.0
Modelling and Forecasting	2.0	
Prospecting Development	1.0	
Technology Development		15.7
Aerodynamics	1.2	
Structural Dynamics	1.1	
Materials Characterization and Fatigue Testing	1.1	
Darrieus Vertical Axis Research	1.4	
Research and Testing at Small Systems Test Center, Rocky Flats, CO	2.5	
Troubleshooting and System Improvements on Large Systems	5.0	
Cooperative Research on Loads, Stresses and Fatigue Problems of Small Systems	2.0	
Small Wind Systems for Agricultural Applications (passthrough to USDA)	1.4	
Engineering Development		23.0
Mod-5 Advanced Multi-Megawatt Systems: Complete Federal Share of Cost-Shared Development	20.0	
Complete Operational Field Testing of Mod-2 Cluster at Goodnoe Hills, WA	3.0	
Total Wind Energy Conversion Systems		44.4

Ocean Energy Systems

Ocean Thermal Energy Conversion (OTEC) systems utilize the temperature gradients between ocean layers, applied through a heat transfer mechanism, to drive turbine electric generators. OTEC applications include baseload electricity production for on-shore use and production of energy-intensive products, such as ammonia, on board OTEC platforms themselves.

Technical and economic assessments of OTEC technologies can now be based on the successful operation of both the 18kw (net) Mini-OTEC and the one megawatt test facility, OTEC-1. However, economically competitive commercial-scale plants will be much larger—on the order of 200-400 MW. Achieving OTEC's potential will require design, construction, and operating experience with an OTEC system which more closely approximates a commercial-scale plant. Consequently, this budget proposal provides for Federal cost sharing of preliminary design studies for specific OTEC pilot projects.

Additionally, continued Federal support is needed—and provided for in this proposed budget—to refine OTEC components and engineering techniques, to support continued research on advanced OTEC concepts (such as open cycle modifications), and continued work on alternative ocean energy devices.

OCEAN ENERGY SYSTEMS

PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Management Planning and Analysis		2.8
Technology Development		8.0
Heat Exchanger Tests	1.5	
Ocean Engineering	5.5	
Biofouling and Corrosion	1.0	
Engineering Test and Evaluation—Pilot Plant: Phase 2—Preliminary Design		4.0
Advanced Research and Development		6.0
Alternative Ocean Energy Concepts	2.0	
Open Cycle Subsystems	4.0	
Total Ocean Energy Systems		20.8

Renewable Energy Information

Easily accessible and reliable information about renewable energy is critical to its continued and timely development. The Federal government is playing an important role in this area through the production of technical information oriented toward the research and industry communities, and by maintaining a consumer information service accessible by mail or by a toll-free telephone system. Because the Federal government has been—and should continue to be—central to renewable energy research efforts, it will continue to be the appropriate agent for collecting and publishing technical reports on renewable energy. Consumer information, while still beyond the capability of the renewable energy industry, should increasingly be provided through private means, as the industry develops the financial base to support it.

We are proposing a two-part Federal program in the renewable energy area to meet these information needs. It would continue funding in 1983 for the two most fundamental elements of the existing Federal renewable energy information program.

The Solar Energy Research Institute currently houses a project for the collection, packaging and publication of Federally-supported research products in the renewable energy area. This is an essential service, because research results are often not refined to the extent that they become useful to anyone other than the researchers themselves. Essentially, taking these materials one step further significantly extends their value to the technical and industry communities—as well as their value to the entire nation. A related activity is conducted by the National Technical Information Service. However, the products of that work are not as well refined as the SERI products, nor are they as accessible. Furthermore, SERI, as the leading national laboratory in renewable energy research, is the most appropriate place to conduct this activity.

The National Solar Heating and Cooling Information Center (NSHCIC), operated by the Franklin Institute in Philadelphia, has for several years been conducting for the Federal government a consumer-response service on renewable energy building applications. Its mandate was recently broadened, to include other renewable energy and energy conservation technologies, and it was renamed the Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS). It is important that the Federal government continue funding for this activity in 1983, to provide energy consumers with reliable information on renewable energy options. However, recognizing the need for the private sector to begin carrying a greater responsibility in the consumer information area, the Franklin Institute, through its newly-formed Energy Technology Transfer Center, and leading renewable energy industry and consumer groups are exploring ways to develop a self-sustaining information service. By blending the experience of the Franklin Institute in the areas of document publication and consumer services with the technical expertise and market awareness of industry and consumer groups, a comprehensive, accessible, technically sound and commercially viable renewable energy information network can be developed. We hope that this working relationship can begin in 1984. But for 1983, we are recommending continued funding for the operation of CAREIRS.

RENEWABLE ENERGY INFORMATION
PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Renewable Energy Information		5.0
SERI Technical Information Project	3.0	
Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS)	2.0	
Total Renewable Energy Information		5.0

Renewable Energy International

The market for U.S. renewable energy technologies, at this time, is largely an overseas one. U.S. industries dominate that still-developing market with technologies that generally equal or surpass those of other countries. They are now receiving stiff competition, however, from foreign countries that are adopting U.S. technologies and subsidizing their further development and overseas promotion. The U.S. renewable energy industry, recognizing the importance of the international market, has formed the Export Council for Renewable Energy (ECRE), to help focus its efforts in the export area.

U.S. industry, in general, has not traditionally marketed overseas in an aggressive fashion, and no export promotion infrastructure exists in this country—such as an export trading company—comparable to those that exist in other countries. Furthermore, our renewable energy industries, for the most part, still lack the financial resources necessary to support export development activities on their own.

Considering the value of the international renewable energy market, both to the development of our domestic industry and to the overall U.S. trade balance, the Federal government has supported export development activities in the renewable energy area. The DOE Renewable Energy International Program has conducted international market research, export seminars for U.S. businesses and overseas trade shows to bring U.S. producers and potential foreign buyers together. These activities have been highly cost-effective, as was demonstrated in a recent GAO study. They generated millions of dollars in sales of U.S.-made systems at a cost of only a few hundred thousand dollars.

The DOE Renewable Energy International Program has been terminated. The Department of Commerce, however, through its International Trade Administration, conducts similar activities on behalf of U. S. industry in general. It does so on a full-cost-recovery basis, and, while U.S. renewable energy industries are more than willing to share the cost of this service, most of them simply cannot yet bear it in full.

We are proposing, therefore, that until U.S. renewable energy industries develop the financial base and the expertise to conduct export development activities, the DOE Renewable Energy Program share their costs of participation in the Commerce Department's international trade services. We strongly believe that such support is necessary—and cost-effective, from the government's point of view—if the U.S. is to retain its lead in the renewable energy sector that it has been so instrumental in creating.

One other aspect of the international renewable energy trade area that deserves Federal attention is the role of the International Standards Organization (ISO). This body sets standards, to which commodities being traded internationally are held, and are important guarantors of product quality. These standards can also be abused, however, through the inclusion of unnecessary and irrelevant considerations. The standards can then become effective barriers to the trade of products from certain countries or companies. This is a long-standing tactic in the international trade arena, and already has been attempted in the area of renewable energy. The surest way to avoid discrimination of this sort is to actively participate in the activities of the ISO, and to promote the adoption of reasonable and consistent standards.

It is important, we believe, that the Federal government assist the U.S. renewable energy industry in its active participation in ISO activities. Here again, a small Federal investment can bring a substantial return through the success of U.S. renewable energy technologies in the world market.

This budget recommendation also contains funding to complete the U.S. share of the SOLERAS Project, a multi-technology, bilateral project conducted by this country and Saudi Arabia.

RENEWABLE ENERGY INTERNATIONAL

PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Renewable Energy International		11.5
International Market Development	2.0	
Trade Missions and Fairs; Export Seminars; International Standards Organization Activities		
SOLERAS Project	9.5	
Total Renewable Energy International		11.5

Program Support

The Program Support fund was instituted during the 1982 budget process, to provide funds to the DOE Renewable Energy Program managers, that they could use to offset unforseen expenses associated with the programs' activities. Formerly, funds for these purposes were set aside through a tax on individual technology program accounts. This complicated the planning of program activities by Congressional committees and by the technology program managers themselves. Creation of a separate Program Support account has resolved this problem, and we recommend that it be continued.

PROGRAM SUPPORT

PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Renewable Energy Program Support	4.0

Solar Reserve Account

The Solar Reserve Account was instituted during the 1982 budget process, and contains funds to offset the cost of important renewable energy development activities that are not assumed as expected by the private sector. In 1982, funds are being drawn from this account, with the permission of the Congressional Appropriations Committees, for support of activities in the passive solar, biomass and solar thermal technology areas, and to help pay termination costs for the Regional Solar Energy Centers.

One specific activity that is being supported with Solar Reserve Account funds is the Deparment of Energy's and the National Oceanic and Atmospheric Administration's project in solar resource assessment. This activity has a value applicable to a number of renewable energy technologies. Thus, it is appropriate that it be funded from a cross-cutting program account such as the Solar Reserve Account. Solar radiation assessment, as well as the recording of climatological data for specific sites around the country, is absolutely fundamental to an accurate understanding of the potential of various renewable energy technologies. The federal government is uniquely suited for this task, because of NOAA's central role, and because it is, at this time, beyond the capability of the diverse and regionally-focussed renewable energy industry.

One other activity that we believe is appropriate to the Solar Reserve Account is assisting renewable energy industries and professional groups make use of research results and materials that have been compiled by the DOE Renewable Program. Renewable energy interest groups, particularly the industries, have been frustrated at their inability to make use of the Renewable Energy R&D Program's products. Considering the way the programs have already been scoped down, assisting them in doing so now would permit the saving and practical use of valuable materials that might otherwise never be applied. A series of contracts with leading renewable energy industry and professional groups, on a one-time basis, would facilitate an accelerated transition of renewable energy from the public to the private sector, and would enhance the value of the federal investment in renewable energy made so far.

SOLAR RESERVE ACCOUNT

PROPOSED FY 1983 BUDGET
(budget authority in millions of dollars)

Solar Reserve Account			3.0
Solar Radiation Assessment		1.5	
NOAA Satellite, Ground Measurements	1.0		
SERI Spectral Measurements	0.5		
Technology Transfer Contracts		1.5	
Total Solar Reserve Account			3.0

Senator DOMENICI [presiding]. Thank you.

Let us proceed now, Jack. We want to hear your views please.

STATEMENT OF JOHN A. CASAZZA, CHAIRMAN, ENERGY COMMITTEE, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

Mr. CASAZZA. Mr. Chairman and Senator Ford, my name is Jack Cassaza. I am chairman of the IEEE Energy Committee. The IEEE is the Institute for Electronic and Electrical Engineers, USA. It is the world's largest technical professional society. We have over 215,000 members. Our work is in the electrical field. We have experts in electronics and electrical power, generation, distribution, and storage and so on.

Rather than give you a wish list of all the things we would like to have, but you are not going to be able to put in our Christmas bag, we thought we ought to provide some context for the tough job you have to do in tearing down the budget and coming up with something that is doable in this country.

We believe that, first, the U.S.A., must contain our overall growth of energy. No. 2, we must diversify our sources to be able to handle the uncertainties that come down the road. And No. 3, We have to do both of these things while maintaining a healthy economic society.

In order to contain our overall energy consumption, it is essential that we make significant reductions in the amount of energy we use for various purposes. Our projections indicate that from now through the year 2000, we are roughly going to have about 20 quads of additional energy resources we are going to have to devote to take care of our growth for economical purposes and perhaps another 10 to 15 to offset our need for foreign oil.

That is perhaps a total growth in our energy resources of about 30 quads. Our estimate on the energy committee shows that the renewable resources, which right now are about 5, are going to have to grow to about 13 quads. In other words it is going to have to be an increase in renewables of about 8 of the total of 30, as we see it from our studies.

I think this provides prospective as to the role of the renewables and it is going to have to be a significant role. If we don't diversify our energy resources, we are going to be in the position where we are continuing to be dependent on foreign oil resources. These resources are politically vulnerable, as you know, and if we rely solely on market sources we may not develop the alternatives in sufficient time.

Senator DOMENICI. What percent of the total would the 13 be, do you know, not total new but total?

Mr. CASAZZA. Of the total of that would be 13 and about 100, which would be 13 percent.

Senator DOMENICI. By the turn of the century you are saying then——

Mr. CASAZZA. We would come out with a 100 quads as a total national lead by the turn of the century. So it would be 13 percent of the national lead from renewables.

Senator DOMENCI. That seems to be within the sum of the projections made by the groups interested in particularly this kind of energy, but it seems rather high based upon other evaluations. There must be something in that that is large and rather conventional. Is wood in there?

Mr. CASAZZA. Wood is, biomass and hydro are both in there, because these are both renewables as we see it. And it comes to 13—perhaps it might be of interest that our figures indicate that perhaps 7 quads will come from new housing designs, which will require some drastic changes in the way we build homes. I think we need to find out how to do these things so we can do them with the maximum efficiency and economy.

We have got to incorporate to get this 13 quads and pass solar heat through all our new houses, and it is the best of all possible heating systems, to get this 13 quads.

Senator DOMENICI. I think we will get that in our new homes, because they are going to be so little, that we will save a lot.

Mr. CASAZZA. We are going to need—well, I am not here to represent the housing industry. I am sure you know their views. We are going to have to have some penetration of photovoltaics in our energy network. We are going to need to build some 35,000 windmills. And another key problem from our systems, we are going to have to integrate storage of dispersed technologies into the overall existing systems. That is going to take a lot of research and work to make these work in conjunction with the utility systems that exist.

Clearly, we are going to need a lot of research. We don't think this budget has the balance it needs to provide the research in these key areas. So it is a real problem with budget. We need budget balance and we need to make some changes in that.

To conclude, we see the vital needs of this program as something that is going to contain our growth to what we can do and diversify our sources. We ask that you consider these comments in doing that difficult job.

I would like to thank you for this opportunity. And if you have any questions we would like to answer them later.

[The prepared statement of Mr. Casazza follows:]

THE INSTITUTE OF
ELECTRICAL AND
ELECTRONICS
ENGINEERS, INC.
TECHNICAL ACTIVITIES BOARD/UNITED STATES ACTIVITIES BOARD
ENERGY COMMITTEE

Statement of Mr. John A. Caszaza
Before the
Subcommittee on Energy Research and Development
of the Senate Energy And Natural Resources Committee
April 26, 1982

on behalf of the
IEEE Energy Committee

Mr. Chairman, and Members of this Subcommittee, it is a pleasure to appear before you today and address the Administration's proposed budget for Federal Energy Research and Development activities for Fiscal Year 1983. The Institute of Electrical and Electronics Engineers, Inc. (IEEE), is the world's largest technical professional society, with over 215,000 members worldwide, over 180,000 of whom live and work in the United States. Our members have expertise in all aspects of electrical and electronics engineering, including power generation, distribution, and storage.

Rather than providing you with a wish list for increased funding over the Administration's proposals for Federal Energy Research Activities for Fiscal Year 1983, I would like to provide a context for reviewing the budget by presenting the IEEE Energy Committee perspective on our nation's three foremost energy needs between now and the year 2000. First, we must contain the growth of our overall energy consumption. Second, we must diversify the sources we rely on for our energy. Third, we must accomplish these first two objectives in a manner that allows us to maintain a healthy economic expansion.

In order to contain our overall energy consumption, it is essential that we effect a formidable energy conservation effort. Projections of energy use in the year 2000 range from 70 to 170 Quads, depending on the assumptions made about population, economic growth, changes in the energy-economic relationships, and so forth. Since the price of oil skyrocketed, we have already seen changes in the relationship between economics and energy. It is generally accepted that we can contain demand to 90 to 110 Quads in the year 2000, or roughly 10 to 30 Quads above our current consumption levels.

Diversification of our energy sources is essential in order to reduce our dependency on fuel supplies which are both rapidly depleting and vulnerable to political instabilities. Right now we are about 90% dependent on non-renewable resources, almost 20% of which is imported oil. It is clear that even if we are able to contain our overall energy consumption growth to 100 Quads in the year 2000, we must rely much more heavily on conservation and on new, dispersed technologies. The IEEE Energy Committee estimates that by the year 2000, our reliance on renewable energy sources, including solar, wind, hydropower and organic sources, must grow from its current share of 5 Quads to 13 Quads of our energy supply picture. To achieve these objectives from solar and renewable resources, based on today's technology, will require:

- That all new housing starts incorporate passive solar designs,

- that solar photovoltaics achieve significant penetration into our electric energy network,
- the construction of over 35,000 windmills,
- and the resolution of many problems associated with the integration of dispersed power generation and storage into our electric power systems.

Clearly, much research is needed if we are to meet these challenges.

The Administration's budget recommmendations for Fiscal Year 1983 for conservation, solar, and renewable resources relies almost entirely on market forces to determine the development of more energy efficient and renewable technologies. If the only concern in our energy scenario were the slow depletion of non-renewable resources, perhaps we could afford to rely solely on market forces. However, due to the political instabilities of our sources of imported oil, market forces may falsely depict the necessary timeframe for bringing these technologies on-line. That is, political events may well outpace market forces, resulting in the need to bring these technologies on-line in a timeframe that is unrealistic under the Reagan Administration budget assumptions.

A second problem we have with the Administration's recommendations in the conservation, solar and renewable area is one of balance. We applaud the attempt to reduce spending by the Department of Energy. However, the conservation, solar and other renewables budget is proposed to be slashed from about $518 million in FY 1982 to slightly over $100 million in FY 1983. When compared to increases in the defense and basic energy sciences areas, and only minor reductions in the nuclear programs, the proposed funding levels for conservation, solar, and other renewable resources are not commensurate with the role these technologies need to play. Increased funding is needed over that proposed in the budget to contain our growth in energy consumption, diversify our sources of energy, and maintain a viable economy in light of future world uncertainties.

Thank you for this opportunity to share our views with you on these important issues. We would be happy to respond to any further questions you may wish to pose at this time, or submit to us later in writing for inclusion in the record.

Senator DOMENICI. Let me ask you a question somewhat unrelated. Does your society or institute have a group that concentrates on our efforts to continue to produce enough engineers of the type that are in your group?

Mr. CASAZZA. Yes, we do.

Senator DOMENICI. What do you call that?

Mr. CASAZZA. Bill Herrold, what is its official title? Manpower Task Force.

Senator DOMENICI. Does the Manpower Task Force have any current recommendations or evaluations on what we are doing wrong as a nation in terms of that? Do you know, Jack, or does the young man back there know.

Mr. CASAZZA. This is Bill Herrold, secretary to the energy committee.

Mr. HERROLD. I can provide you with further information on that task force.

Senator DOMENICI. Do you have a specific, current task force evaluation on that issue? Are we doing all we can to assure America of an adequate supply of well-educated people in this discipline?

Mr. HERROLD. I think the committee would think we are not.

Mr. CASAZZA. The view of the institute is we are not.

Senator DOMENICI. I understand that. Have you done anything official in response to that precise issue that is in written form that you can give us?

Mr. HERROLD. I believe so and I will get that for you.

Mr. CASAZZA. We will do that, Senator.

[Subsequent to the hearing Mr. Casazza submitted the following:]

THE INSTITUTE OF
ELECTRICAL AND
ELECTRONICS
ENGINEERS, INC.
TECHNICAL ACTIVITIES BOARD/UNITED STATES ACTIVITIES BOARD
ENERGY COMMITTEE

PLEASE REPLY TO:
John A. Casazza
Ransom & Casazza, Inc.
1000 Connecticut Avenue, NW
Washington, DC 20036
(202) 466-2036

June 17, 1982

Senator Pete V. Domenici, Chairman
Subcommittee on Energy Research and Development
Senate Committee on Energy and Natural Resources
Room S-404 Capitol Building
Washington, D.C. 20510

Dear Senator Domenici:

When I testified before your Subcommittee on April 26, 1982, you made two inquiries for which I indicated I would provide answers for the record. These inquiries, as we understand them, along with our responses to them, are as follows.

1. On what basis do we project that solar and renewable energy resources will provide the U.S. with 13 Quads of energy in the year 2000?

   Below I have listed the source mix which we believe is necessary if we are going to secure these 13 Quads.

ENERGY SOURCE	QUADS 1980	QUADS 2000
Solar Residential and Commerical Heating, Hot Water, Cooling	-	2.5
Biomass	1.8	4.5
Hydroelectric	3.0	4.0
Wind	-	1.0
Solar Electricity	-	0.5
Geothermal Power Plants	-	0.5
	4.8	13.0

Should you have any more detailed questions about any of the projections listed above, we would be happy to provide you with additional information as to how these estimates were reached.

2. Does the IEEE have a position on Engineering Manpower Shortages?

IEEE has taken a position with respect to engineering manpower shortages. We have furnished comments on this subject at various times to the Labor Department, to various committees of Congress in their consideration of immigration issues, and to others in response to questions as to whether an engineering manpower shortage does exist. Our position has been that issues of engineering supply and demand are complex and cannot be reduced to broad statements that there are shortages or oversupplies at any given time. Supply and demand must be examined in terms of specific geographic areas, specific technical specialties and subspecialties, and specific industries. Trends in any of these areas change rapidly due to the introduction of new technologies, due to changes in Federal spending, and most significantly due to fluctuations in the economic health of the United States. Engineering manpower in this country is not utilized in the most efficient manner. An appreciable change by much of industry in the use of technical resources would help, to some degree, to stabilize the employment cycles experienced by engineers.

We have attached an issues paper which is still in preparation and which comments on many aspects of the engineering manpower shortage issue. Since we are aware of your interest, we will send you additional information on the IEEE position on this matter as it develops.

We hope this has been responsive to your interests, and I look forward to hearing from you should you wish any additional information.

Sincerely,

Jack Casazza

John A. Casazza, Chairman
IEEE Energy Committee

amc
Attachment

PREDICTING ENGINEERING MANPOWER DEMANDS

SOME CONSIDERATIONS

Draft Report prepared by

Robert A. Barden
Manpower Task Force
IEEE United States Activities Board

October 1981

PREDICTING ENGINEERING MANPOWER DEMAND-SOME CONSIDERATIONS

Introduction

The Institute of Electrical and Electronics Engineers is the largest technical professional society in the world. In the United States, its membership includes over 150,000 electrical, electronic, and computer engineers. Because of this constituency, one of the Institute's high priority concerns is the availability, quality, and utilization of engineering manpower.

Vital to the understanding of these issues is carefully prepared, in-depth data, and the equally careful analysis of all available data. Recent projections and predictions of demand for engineers have ranged from those showing serious shortages through the 1980's to those predicting engineering oversupply and layoffs. In an effort to determine the reasons for this wide range of conclusions, the IEEE convened a meeting in Washington, DC on November 16 and 17, 1981 to which representatives of the National Science Foundation, the Engineering Manpower Commission, the College Placement Council, the Department of Defense, various industry and professional associations, and congressional staff were invited. We believe that the presentations given and discussions held at that meeting went a long way toward resolving some of the discrepancies between some present projections and toward a better understanding of the full complexity of the problem.

Some of the points made during the meeting were:

- Engineering is such a multifaceted entity that demand (or lack of it) for engineers as a whole cannot be interpreted to extend directly to each discipline (e.g., a demand for "engineers" does not necessarily mean that there is a demand for mechanical engineers).

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- Each engineering discipline is sufficiently stratified that demand (or lack of it) for, say, electrical engineers, does not mean that there is a demand (or lack of it) for, all specialties of electrical engineers.
- Demand created by geographic anomalies (such as the high cost of housing or high tax rates) cannot be extrapolated to indicate a national demand.
- Demand for engineers has historically been driven by the national economic health more than any other factor.
- Extreme caution must be excercised in examining any particular survey methodology and sampling before even considering the merits of manpower projections based on any specific survey.
- There is an apparent shortage of qualified engineering faculty, due primarily to the wide gap between industry salaries and low academic salaries.
- Inadequate and inappropriate utilization of engineers increases demand. The increasingly efficient use of existing technically skilled manpower can be implemented immediately and decrease the pressure for more engineers.

Each of these points is expanded upon below.

The Structure of Engineering

As shown in Attachment 1, Engineering is part of the technical work force classified by the National Science Foundation as Scientific/Engineering (S/E) Manpower. Engineers are concerned with the useful application of scientific principles. Engineering is divided into disciplines such as mechanical engineering, electrical and electronics engineering, petroleum engineering, etc. The Engineering Manpower Commission of the American Association of Engineering Societies recognizes twenty-one engineering disciplines.

Within each engineering discipline are various specialties. The IEEE recognizes thirty-one specialties within electrical/electronic engineering. The work, employer types, and job markets of engineers employed in different specialties and in different disciplines can be quite diverse. For example, Attachments 2 & 3 show one measure of demand (salary increase over the period 1978-1980) for various types of engineers. In Attachment 2, it can be seen that salary increases indicate a strong demand/short supply of petroleum engineers, while the same data shows little demand/adequate supply of aerospace engineers. It should be noted that overall, salary increases have not kept up with inflation over this period; the 15.7% average increase (Attachment 3) for electrical/electronic engineers was reduced by a 26.3% increase in the Consumer Price Index.

In reviewing the two attachments, it becomes obvious that any conclusions about supply and demand based on one discipline or specialty will not necessarily be true for other disciplines or specialties, or for engineering as a whole. Conversely, any conclusions drawn from averaged data for all engineering may not be directly extended to specific disciplines or specialties.

Geographic Anomalies

Demand for engineers may vary greatly with geographic location. This variance may be due to sudden increases or decreases in local demand, such as those caused by plant closings, or the award of one or more large contracts to companies located near each other. The variance may also be caused by factors external to the engineering market place, such as a locally high cost of living or locally high cost of housing. (There may also be general impediments to relocation to any part of the country, such as high mortgage interest rates.)

Increases in demand due to local factors are illustrated by the following two examples. Two areas of the country which have been identified as experiencing a high demand for engineers are Boston and California. Each is examined below.

Attachment 4 shows three factors for various urban areas of the country. The first factor is average 1980 electrical/electronics engineering salaries in each of several cities normalized to the national average electrical/electronics engineering salary. Engineers in the Boston area, for example, make 1.059 times the national average for engineers.

The second factor is the Bureau of Labor Statistics Urban Family Budget, normalized to the average urban United States. The specific budget selected was that for a higher-budget 4-person family.

The third factor is obtained by dividing the normalized salary by the normalized budget. Intuitively, this factor gives an indication of the buying power or the discretionary income of engineers in various locations. The lower the ratio, the less discretionary income (the less economically desirable the area); the higher ratio, the more discretionary income (the more economically desirable the area). It should be noted that housing costs which are factored into the budget are for homeowners who have owned their homes for six years; the factor could be significantly different for new homeowners.

Attachment 4 shows that the Salary/Budget factor for Boston is the lowest of the seven major urban areas examined. It can be inferred, then, that of the seven areas, the (economically) least desirable place to live is Boston. A detailed examination of the

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breakdown of the BLS budget for Boston shows that, of the twenty-five urban areas selected for analysis, Boston is highest in homeowner housing cost and third highest (behind New York and Honolulu) in personal income taxes. Yet National Association of Realtors statistics show that the cost of the house itself is lower in Boston than in other urban areas, implying that the high homeowner housing cost in Boston is due to taxes, interest, and insurance. Because of the common basis of the the BLS statistics, the differential in Boston housing is then mostly higher taxes.

The reported high demand for engineers in the Boston area is due in part, then, to the economic unattractiveness of living in the Boston area. This economic unattractiveness, in turn, is due largely to high property taxes and to high personal income taxes. A first step toward solving this local demand might well be the relaxation of taxes in the area, a local issue.

The second example of demand based on local factors is that of the reported high demand for engineers in California, particularly in Los Angeles and San Francisco. The Salary/Budget Factor of Attachment 4 would indicate that Los Angeles and San Francisco are economically desirable places to live. As noted above, however, the homeowner housing costs included in the Budget Factor are for homeowners who bought their homes six years ago. Statistics compiled in 1981 by the National Association of Realtors show that a newly purchased home in the San Francisco area costs 73% more than the national average and a newly purchased home in the Los Angeles area costs 52% more than the national average. These significantly higher costs, coupled with present high mortgage interest rates, make it difficult for someone living outside of California to relocate to Los Angeles or San Francisco. Obviously, relocation problems apply to non-engineers as well; it is receiving great attention with respect to engineers because traditionally engineers have been able to relocate easily. Some California companies are dealing with this problem by locating new facilities in other states, where housing costs are lower, or by subsidizing new home costs for newly relocated employees. Again, this is a local (but nontheless important) problem, which is not necessarily indicative of a national shortage of engineers.

Engineering Demand Projections

Historically, attempts at making projections of demand for engineers have met with little or no success. Usually, projections had been made based on surveys of employers in which they were asked to predict their needs for engineers. This technique led to inaccuracies for several reasons, including employer optimism, double counting of future opportunities, and the reluctance of employers to publicly announce layoffs before they occur.

Employer optimism and the reluctance to prematurely announce layoffs or reductions are self-explanatory, but the double counting of future employment opportunitites deserves further explanation. If two or more companies have submitted competitive bids for major contracts (such as two or three airplane manufacturers bidding on a new fighter plane), and each is asked what its engineering manpower needs will be for the next five years, it is likely that each will answer based on winning the contract. The contract, if awarded at all, will be awarded to only one of the competitors, and the total demand for engineers will be only a fraction of the total reported demand. While this effect is most noticeable with large contracts, it is also present in microcosm with smaller companies competing for the same contracts.

These factors have combined with economic factors to make demand projections based on simplistic surveys virtually useless. The Engineering Manpower Commission recognized this in the early 1970's and discontinued their long-range demand forecasts. They are now experimenting with twelve month projections based on more sophisticated techniques.

It became apparent that demand for engineers is more closely linked to the general state of the economy than to any other single factor. Attachment 5 shows engineering unemployment and the Gross National Product plotted for the periods 1960-1981. Also shown are lines indicating the various Presidential administrations during this period. It should be noted that historically unemployment has been up during Republican administrations and down during Democratic administrations. The close correlation between engineering unemployment and gross National Product (with unemployment up when the GNP is down) should also be noted: herein lies the problem in predicting demand. With such a close correlation between GNP and engineering demand, one who wants to predict accurately engineering demand must first be capable of predicting accurately the economy (as reflected by the GNP). Simplistic surveys, often used to project demand, are, to say the least, inadequate for the job at hand.

Sectors Of The Engineering Community Deserving Special Attention

Within the engineering profession, there are specific sectors which are suffering from shortages of qualified people, notably education and the military.

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In the case of university professors of engineering, the most often cited reasons for the shortage are the lack of up-to-date research equipment on campus and the low salaries of professors, when compared to the industrial salary base.

In order to rectify this situation, various companies and industry groups have started, or expanded, grant programs to engineering colleges. While we heartily laud these efforts, it would seem that it will also be necessary to raise engineering faculty salaries to the level necessary to attract well-qualified graduates into faculty track positons, even if this is funded by assessing incrementally higher tuition in the engineering programs.

Military engineers suffer from similar differentials in pay scale when compared to industrial positions requiring similar experience, leading to low retention rates. This, too, is a complex problem, and we have opened a dialogue with Department of Defense personnel to explore potential remedies.

Utilization

The product development of the electronics industry is unparalled in the terms of increasing national productivity. Yet the utilization of engineering manpower which makes these productivity increases possible remains poor. In many companies, engineers are used to perform work that technicians and technologists could readily do as support work. Companies that provide the engineers with this kind of support do not claim shortage problems. The problem of U.S. companies underutilizing or misutilizing engineers is so severe that a major study is being conducted to correct the engineering career conditions.

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Any correct assessment of engineering supply and demand must include an understanding of the utilization problem.

Summary

The demand for engineers historically has been more closely related to the general economic health of the country (as measured by the GNP) than to any other factor. This has made the prediction of demand for engineers difficult, if not impossible.

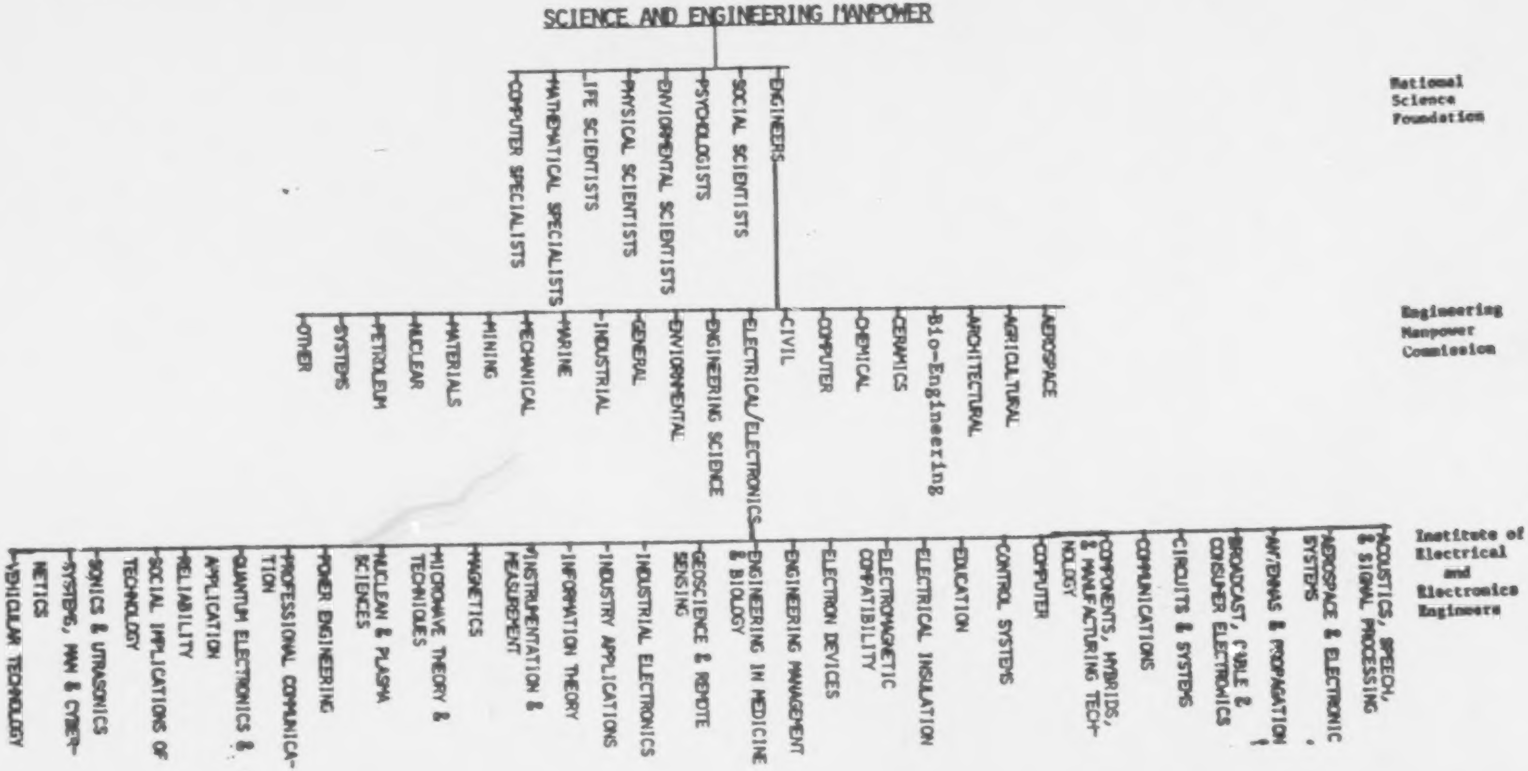
Furthermore, present demand for "engineers" does not extend to all disciplines or specialties of engineering; nor can demand for a specialty be extrapolated to include other specialties or the entire profession.

Caution must also be excercised that demand due to geographical anomalies is not extrapolated to indicate demand on the nationwide basis.

Special attention is being given to the university and military manpower problems. The improved efficiency of engineering manpower utilization will affect the demand figures as presently perceived by much of industry.

ATTACHMENT 1

THE CLASSIFICATION OF ELECTRICAL AND ELECTRONICS ENGINEERS WITHIN THE SCIENCE AND ENGINEERING MANPOWER DISCIPLINES


SCIENCE AND ENGINEERING MANPOWER
National Science Foundation
ENGINEERS
SOCIAL SCIENTISTS
PSYCHOLOGISTS
ENVIORMENTAL SCIENTISTS
PHYSICAL SCIENTISTS
LIFE SCIENTISTS
MATHEMATICAL SPECIALISTS
COMPUTER SPECIALISTS
Engineering Manpower Commission
AEROSPACE
AGRICULTURAL
ARCHITECTURAL
Bio-Engineering
CERAMICS
CHEMICAL
COMPUTER
CIVIL
ELECTRICAL/ELECTRONICS
ENGINEERING SCIENCE
ENVIORNMENTAL
GENERAL
INDUSTRIAL
MARINE
MECHANICAL
MINING
MATERIALS
NUCLEAR
PETROLEUM
SYSTEMS
OTHER
Institute of Electrical and Electronics Engineers
ACOUSTICS, SPEECH, & SIGNAL PROCESSING
AEROSPACE & ELECTRONIC SYSTEMS
ANTENNAS & PROPAGATION
BROADCAST, CABLE & CONSUMER ELECTRONICS
CIRCUITS & SYSTEMS
COMMUNICATIONS
COMPONENTS, HYBRIDS, & MANUFACTURING TECHNOLOGY
COMPUTER
CONTROL SYSTEMS
EDUCATION
ELECTRICAL INSULATION
ELECTROMAGNETIC COMPATIBILITY
ELECTRON DEVICES
ENGINEERING MANAGEMENT
ENGINEERING IN MEDICINE & BIOLOGY
GEOSCIENCE & REMOTE SENSING
INDUSTRIAL ELECTRONICS
INDUSTRY APPLICATIONS
INFORMATION THEORY
INSTRUMENTATION & MEASUREMENT
MAGNETICS
MICROWAVE THEORY & TECHNIQUES
NUCLEAN & PLASMA SCIENCES
POWER ENGINEERING
PROFESSIONAL COMMUNICATION
QUANTUM ELECTRONICS & APPLICATION
RELIABILITY
SOCIAL IMPLICATIONS OF TECHNOLOGY
SONICS & UTRASONICS
SYSTEMS, MAN & CYBERNETICS
VEHICULAR TECHNOLOGY

ATTACHMENT 2
ENGINEERS' SALARIES BY EMPLOYMENT GROUP, 1980-1981

EMPLOYMENT GROUP	1980 MEAN*	1981 MEAN*	% INCR
PETROLEUM	$35,350	$41,850	18.4
CHEMICAL	34,500	37,100	7.5
MINING		36,500	
AEROSPACE	32,450	32,650	0.6
CONSTRUCTION & MINING	31,150	32,600	4.7
ELECTRICAL & ELECTRONIC EQUIP	30,950	32,750	5.8
RESEARCH & DEVELOPMENT	30,450	37,150	22.0
DESIGN, CONSULTING & ENG SVCS	30,250	29,950	-1.0
UTILITIES SERVICES	30,200		
FEDERAL GOVERNMENT	29,450	31,800	8.0
MECHANICAL INDUSTRY	28,750		
METAL INDUSTRIES	28,350	30,600	7.9
LOCAL GOVERNMENT	27,150	29,700	9.4
ALL EDUCATION	26,650		
STATE GOVERNMENT	24,600	26,950	9.6

*THESE ARE ACTUALLY 1979 AND 1980 SALARIES REPORTED IN 1980 AND 1981 PUBLICATIONS.

SOURCE: ENGINEERING MANPOWER COMMISSION

ATTACHMENT 3

SALARY GROWTH vs PRIMARY TECHNICAL COMPETENCE FOR EE's

CATEGORY	1981 MEAN*	1979 MEAN*	% INCR
MINI-COMPUTERS	35,376	$29,952	18.1
MICRO-COMPUTERS	35,954	28,384	26.7
COMPUTER PERIPHERALS	36,076	30,616	17.8
DP SYSTEMS INTEGRATION	38,074	32,069	18.7
HARDWARE (COMPUTERS)	34,755	27,237	27.6
SOFTWARE (COMPUTERS)	33,343	28,529	16.9
TEST, MEASUREMENT, INSTR.	34,786	30,088	15.6
COMMUNICATIONS SYS & EQUIP	38,638	32,468	19.0
NAV/GUIDANCE SYS & EQUIP	37,780	32,708	15.5
ELECTRONIC WARFARE	37,152	31,094	19.5
INDUSTRIAL CONTROLS	34,822	29,831	16.7
COMPONENTS & SUB-ASSYS	39,569	34,205	15.7
AIRCRAFT, MISSILES, SPACE	36,759	32,869	11.8
MEDICAL ELECTRONICS	38,589	30,417	26.9
INDEPENDENT R&D, TEST	37,414	34,534	8.3
GOVT AGENCY & MILITARY	34,837	32,435	7.4
INDUSTRIAL COMPANIES USING ELEC PRODS IN MFG, R&D	39,439	32,991	19.5
POWER GENERATION	35,868	33,479	7.1
POWER TRANSMISSION	33,990	29,337	15.9
POWER DISTRIBUTION	32,214	29,626	8.7
POWER PRODUCTION	37,561	32,117	17.0
UTILITIES EXCEPT POWER	38,852	35,223	10.3
AVERAGES	36,659	31,680	15.7

*THESE ARE ACTUALLY 1978 AND 1980 SALARIES REPORTED IN 1979 AND 1980 PUBLICATIONS.

SOURCE: IEEE U.S. MEMBERSHIP SALARY AND FRINGE BENEFIT SURVEY, 1979 AND 1980

ATTACHMENT 4

ENGINEERING SALARIES AND FAMILY BUDGETS FOR SELECTED CITIES

CITY	NORMALIZED SALARY	NORMALIZED BUDGET	NORMALIZED SAL/BUD
BOSTON	1.059	1.20	0.88
NEW YORK CITY	1.132	1.24	0.91
PHILADELPHIA	1.000	1.04	0.96
WASHINGTON DC	1.031	1.09	0.95
CHICAGO	1.008	0.99	1.02
LOS ANGELES	1.071	0.99	1.08
SAN FRANCISCO	1.086	1.07	1.01

NOTE: BUDGET INCLUDES HOUSING BUT ASSUMES THAT HOUSE WAS BOUGHT SIX YEARS AGO

1981 NEWLY BOUGHT HOUSE IN SAN FRANCISCO IS 73% HIGHER THAN THE NATIONAL AVERAGE; 1981 NEWLY BOUGHT HOUSE IN LOS ANGELES IS 52% HIGHER THAN NATIONAL AVERAGE.

SOURCES: DOL/BLS, IEEE, NAR

Senator DOMENICI. Mr. Stronberg, proceed please.

STATEMENT OF JOEL B. STRONBERG, DIRECTOR, GOVERNMENT RELATIONS, BRICK INSTITUTE OF AMERICA

Mr. STRONBERG. Thank you, Mr. Chairman and Mr. Ford. My name is Joel Stronberg and I am here today on behalf of the Brick Institute of America. The institute represents the producers of 80 percent of the brick manufactured in the United States.

Throughout the past year, we have devoted much time and attention to the development of solar energy. Working in conjunction with other organizations, such as the American Institute of Architects, the National Association of Home Builders, the International Union of Bricklayers and Allied Craftsmen, the Northeastern Retail Lumbermen's Association, the Masonry Industry Committee and the Passive Solar Industries Council, we have met with congressional and administration officials in an effort to define an acceptable industry-Government partnership for the development of passive solar resources.

I will be submitting my formal testimony for the record, sir. I would like to briefly summarize it, because I know the time constraints facing the committee. The industry is interested in passive solar for several reasons. We believe it is a contributive solution to the matter of affordable housing in this country.

Senator DOMENICI. Senator Ford is going to conclude this meeting. I have to be at the leader's office in 2 minutes. I apologize. Thank you, Senator Ford.

Mr. STRONBERG. We are interested in both the passive solar, implication of passive solar energy as it contributes to the housing solution, also as it contributes to jobs, materials, development and investment opportunities for the economy.

Throughout the last couple of years, we have been working very hard, I think, to live within the budget constraints facing this country as a result of inflation. There is a certain sense of irritation, I think, on the part of the industry.

Throughout last year, we worked with OMB and tried to explain and prove the point of the investment value of passive solar. There seems to be no discussions to whether or not the Federal dollar invested for this kind of technology, there is no disagreement as to whether or not it produces more money coming into the economy.

We have tried to show balance between long-term and short-term research. We have tried to show that the economic implications solving the rather stalled housing market can have extraordinary multiplication effects throughout the economy. And yet the 1982 budget of the Department of Energy shows not a continuation of the programs but a termination of the programs.

We have taken our case both to the House and the Senate and to the administration and yet moneys are not being spent for the dissemination of information by the designers. Money is not being spent to educate homebuilders to the practices and techniques that are necessary to install passive technology and design on homes.

The entire investment that has gone on over the past 5 or 6 years, and it is a considerable investment, for example the American Institute of Architects throughout the last year dedicated $1 out of every $12 to the education of its architects so that we can increase the efficiency of construction design in this country.

And yet the investment is going no where, because the industry and the Government are not working in concert. We have admitted to the fact that we are not the most sophisticated industry in the United States. We are, however, one of the largest industries. As a construction industry, we contribute $129 billion to the gross national product. As just a residential constnuction industry, we are nearly 4 percent of the gross national product.

There are nearly 12 million people involved in the construction of homes and building in this country. We use an inordinate amount of energy in this country. When the energy crisis first started, we approached the automotive sector, and this is our largest consuming sector, and we said we are going to effect some changes. We are going to effect the OPEC pricing system. We are going to effect the consumptions. We have done that. We have done that fairly successfully.

Now, we must approach the building sector. As a user of 37 percent of the energy, we are the next largest sector that can impact international fuel sources, international pricing of fuel sources. We can effect our own stability. Yet we don't do it.

We are not asking for a large increase in the Federal budget. What we are asking for is better directed Government programs. Throughout the 1960's and 1970's, we spent lots of money on lots of programs. The difficulty, we don't think, is in the expenditure, but it is in the investment.

When the investment option is so clearly presented to the Government, when we can prove that we invest our own dollars, when we can prove that there are jobs back and dollars back because of the money we save, we would expect that the partnership would be furthered. We have not found this throughout the year.

As a result of the opposition, we have gotten very much tougher in our stance. We presented to you and will be presenting to you more formally the building energy research program. We think that we can live within the budgetary levels and yet we think that the investment is worthless if we continue to go to long-term, high-tech, high-risk options.

The opportunities are here today and we of the industry are asking you to take advantage of this. This ends my informal remarks and I think I have elaborated most of the points in my testimony for further consideration.

Thank you very much.

[The prepared statement and additional material submitted by Mr. Stronberg follows:]

Brick Institute of America 1750 Old Meadow Road, McLean, Virginia 22102 Phone: 703-893-4010

STATEMENT OF JOEL B. STRONBERG
ON BEHALF OF THE BRICK INSTITUTE OF AMERICA
BEFORE THE SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

April 26, 1982

My name is Joel B. Stronberg and I am here today on behalf of the Brick Institute of America. The Institute represents the producers of 80 percent of the brick manufactured in the United States. Throughout the past year, we have devoted much time and attention to the development of solar energy. Working in conjunction with other organizations such as the American Institute of Architects, the National Association of Home Builders, the International Union of Bricklayers and Allied Craftsmen, the Northeastern Retail Lumbermens Association, the Masonry Industry Committee and the Passive Solar Industries Council, we have met with Congressional and Administration officials in an effort to define an acceptable industry-government partnership for the development of passive solar resources. Although not always successful in our attempts, we remain committed to the task.

Our concern for the devlopment of alternative energy sources is not limited to the thousands of jobs which would be provided to the economy or even to the extra quantities of brick, glass, wood, metals, etc. which would be manufactured and distributed if the efficiencies of new and existing buildings are increased through conservation and solar techniques. We are equally concerned about the serious consequence of not developing and industrializing all domestic renewable energy supplies. Part of our concern is personal. For example, deregulation of natural gas will serve to increase the costs of producing brick but the effects are not limited to one industry. Without available alternatives the cost of materials to the consumers will rise and the inflationary fire will once again be fueled. Although the private market mechanism may ultimately provide less expensive energy options, it is not likely to do so with sufficient dispatch. Particularly in the case of the construction industry the wait may be very long, and in the meantime, the nation must experience higher costs and continued dependence upon foreign fuel sources. Whether or not one believes in the current existence of an energy crisis, there can be little doubt that the world's propensity to over-consume diminishing resources can lead to economic, social and political disruption. These disruptions may be ameliorated, and possibly prevented, through the development of alternative energy technologies.

In our discussions with the members of Congress, we have emphasized our belief in passive solar technology as both a source of energy and as an important element in the production of affordable housing.

As members of the building industry we are aware of the impacts of inflation on consumers and the current need to de-escalate the costs of living; as members of the building industry, we recognize the need to stimulate economic activity in an otherwise stalled housing market; and, as producers of materials whose primary purpose is their use in the construction of buildings we are knowledgeable about the need to increase the investment value of a house so that home mortgages may better compete in the credit markets. Although the development of passive solar energy will not cure the many economic ills now faced by the building industry, it can serve an important function in the healing process.

Over the course of the last year we met several times with representatives of the Office of Management and Budget. At the first meeting, I, along with other building industry representative, was told that although our arguments on behalf of passive solar were logical that there was nothing which could be done. In response to a collective look of bewilderment one of the OMB staff rose and said somewhat apologetically that our mistake was in believing that it was the philosophy of Calvin Coolidge which governed and not the thought of Herbert Hoover. Although at the time everyone enjoyed the humor of the explanation, we have since begun to feel the sting of its accuracy.

During our discussions with the OMB staff the industry advocated development of a partnership agreement which would reflect the limits of the Congressional budget resolutions, while maintaining the effectiveness of the program. The industry emphasized that its role was in large part determined by the nature of the government's involvement. If the federal structure was responsive to the realities of the industry and produced practical information in a viable form then the industry would respond and the net result would be the rapid application of passive solar technology and design. If, however, DOE failed to understand the need for federal coordination and encouragement and simply placed emphasis upon long-term high risk research then the industry would be left to its own slow process. In its February 19, 1982 report (No. 92-35) the Government Accounting Office (GAO) couculded:

> Many problems exist at different levels of government and within the home building industry that impede the development and use of innovations which could check rising costs. Further
>
> - builders are reluctant to assume risks associated with rising new technology.
> - local building codes are sometimes restrictive and administered inconsistently.
> - builders lack technical information on innovative technology.

There is no reason to believe that the industry is capable of adopting passive solar innovations more rapidly in the future than it has accepted the introduction of other new products and designs in the past. In light of proven partnership concept these delays are unnecessary.

In their reliance upon the private market for the application of passive solar technology the Department of Energy reflects a misunderstanding of the private structure in general and of the building industry in particular. Not to repeat the long litany of description of the unique characteristics of the housing industry, it is sufficient to say that the industry is comprised almost exclusively of small and medium sized businesses and does not readily lend itself to either integrated or extensive research and development activities.

Although the building industry can and does expend its own resources on the development of passive solar designs, systems and products, its capacity is limited. Because passive solar energy must rely upon a building's design and structure, its commercial fortunes are inextricably linked to the construction cycle. The instability of the construction cycle, as exhibited by the historic "dips and surges" of economic activity, is but one indication of the industry's inability to assume full responsibility for the development and application of passive solar technology. The industry's high concentration of small and medium sized businesses means that the number of available research dollars is small. Without an integrative structure such as the Department of Energy, the industry's scarce resources are unlikely to be pooled in an effort to have the most impact. The developmental process is expensive although large industries have for years dedicated their resources to new product development and introduction, this has been an elusive luxury for the construction industry. The building industry, however, is not without its resources. Through its association network, widespread dissemination of federal program results is possible. Through its cadre of engineers, lawyers, product developers, distributors, contractors, etc. it can take the information developed through federal programming and provide valuable in-kind services to the Department's research and planning efforts. Through its relationship with private financial markets it can use federal funds to leverage private investment dollars.

It is important to note at this juncture that the Congress and the Administration have acted to reduce the cost of government simply by decreasing the amount of expenditures. However, cost is also a function of efficiency and rates of return on invested capital. The sin of the sixties and seventies was not that we spent too much but that we invested too little. As the government derives its income through taxation, it is inherently in the national interest to encourage the conduct of productive and taxable activities. If for every one dollar of federal investment three dollars in revenue were generated, our economic woes would be over. There is ample evidence, however, that our system does not strive for such an investment ratio and that it consistently fails to approach problems with an investor's attitude. Yet, according to the Department's own statistics one federal dollar spent in 1981 on behalf of the industry-government partnership would return $125 worth of energy savings. For an investment of less than $400 million between the period of 1978-1985 it would have been possible to realize nearly $50 billion in value of energy saved. It was also estimated that from the industry-government partnership 100,000 new jobs would be added to the economy by the year 2000 and nearly $10 billion a year of new economic activity in the form of sales would be generated.

Because the Department conducted no analysis of the economic impact of their FY '83 solar request and failed to analyze the industrial impact of re-directing the passive program into long-term research efforts, it is not impossible to compare what would have been with what will be under current solar management. It is logical to assume, however, that without attendance to the industrial constituency that the investment ratio will not be nearly as impressive.

Increased federal investment in the development of solar resources is occurring throughout the world. In a recent privately conducted study, it is shown that the United States has outspent the rest of the world in energy development. Despite its past effort, however, this nation has begun to abandon its earlier investment and is rapidly losing its competitive advantage. The United States has failed in the past to work in consort with its industries and, as a result, has suffered dimunition of the markets for American produced steel, automobiles and manufactured products.

Other nations such as France have found it possible to address both ends of the energy producing spectrum and have found no inconsistency in their support of solar and nuclear technology. The choices presented are not mutually exclusive. The country can pursue moderate renewable resource development without facing bankruptcy. The nation is capable of implementing a balanced energy program which attends to the needs of both long- and near-term research and which fosters utilization of both high- and low-technology options. The total disregard of the emerging renewable industry exhibited by DOE is unprecedented and it would appear to be a course which is diametrically opposed to the direction chosen by our world neighbors.

The solar energy program put forth by the Department of Energy not only ignores shorter term application strategies, but through its refusal to acknowledge the government's role as a provider of information it assures that much of the successful programming of the past seven years will be wasted as its results will never be analyzed and placed before the private market in any usable form. If the Department intends to conduct only long-term academic exercises then the solar research function of the Department will never serve the nation's need for reliable alternative energy systems and designs, nor will it serve the industry as it attempts to increase the energy efficiencies of new and existing buildings. Under these circumstances it is at least arguable that the Department should be stripped of any appropriation and the dollars otherwise invested in some productive activity. If, however, this Committee wishes to see federal funds teamed with private resources in a partnership which will both decrease the use of expensive fuel sources and increase productive economic activity, then certain changes in the

Department's proposals must be made.

During the past several months the passive industry has worked with other representatives of the solar and conservation community in fashioning what we believe to be a workable response to the problems I have discussed. Our objective is oriented towards the production of energy-efficient buildings. Because 37% of the energy consumed in the country goes to the heating, cooling and lighting of buildings the impact of a successful government-industry partnership can have enormous positive implications for both the producing and consuming sectors of our economy. The proposed Building Energy Research Program is both an integrated and comprehensive approach to energy research. It is intended to meet the need of building owners and occupants to reduce energy consumption and the need of the building industry to develop cost-effective approaches to reducing conventional energy use. Key aspects of the proposal are:

1. Buildings should be treated as integrated and dynamic energy-using systems. This approach recognizes that greater energy efficiencies can be attained by appropriate coordination of various energy technologies and components within a building or between a building and a larger community-scale system or utility grid. This approach also departs from the more traditional consideration of energy conservation and active and passive solar as separate technologies.

2. The research program should be based upon the actual behavior of occupied buildings. This also represents a departure from the present programs, which mainly infer the behavior of occupied buildings from computer models rather than gathering empirical data from the buildings themselves.

3. Residential and commercial buildings should be treated separately. These buildings have different design and construction techniques, different types of energy systems, and different use patterns. Research should be structured to recognize these differences. Moreover, within each of these categories, existing buildings should be treated separately from new buildings, because the techniques involved in retrofit applications are quite different from those in new construction. It is important to note here that, although it is much easier to incorporate energy efficiency improvements into new buildings, the potential for overall energy savings is much greater through the upgrading of the stock of existing buildings. Finally, multi-family buildings are recognized as a unique problem in both the residential and commercial categories.

4. The research program should be oriented towards the specific needs of those who will apply the research results, namely home builders, architects, engineers, appliance and product manufacturers and retrofitters. This has not been true of the existing programs. To provide the proper orientation, this proposal calls

for the direct involvement of the various members of the buildings sector in the planning and direction of the research program. This kind of partnership can ensure that the resources for energy research of the federal government and of industry will be used most efficiently. It is important to note that considerable data on building energy technologies has been developed through the existing research programs. Even though we are suggesting the redirection of these programs, this data remains valuable, and deserves continued analysis and application within the proposed program.

5. The research program should be balanced between near and long-term development work. It is unrealistic to believe that all the federal government needs to support in this area is basic research. The most promising energy savings lie with nearer term developments. The nature of the buildings industry, as earlier mentioned makes sole support for near-term research by the industry as difficult as support for long-term research. As in the past, however, the industry will continue to lend its resources where appropriate to the application of technologies and strategies developed through the proposed program.

6. An ongoing component of the program will be research into the health and safety aspects of building energy research systems. Recent problems with the indoor air quality of super-insulated structures suggest that attention should be given to potentially adverse side effects of new energy systems and design strategies. This kind of research is most appropriate for the federal government.

Divestiture of near-term progress in the development of passive solars technology and the benefits of increased economic activity within the building sector which would occur as a result is an unwise choice. Yet, it is the choice of the Department of Energy. In the past DOE programs have not always been successful; but, the Department has until recently made an honest attempt to serve industry. Without the last several years of government programming, it is unlikely that the building industry would have so enthusiastically adopted passive solar technology. The Department has a right to be proud of its accomplishments; it also has an obligation to preserve and to build upon their past successes. Examples of the type of DOE programs which have been of value to the industry include:

The Passive Commerical Buildings Program

The Passive Commercial Buildings Program has been a success. It has been successful because it has recognized the role of the architect in the design of commercial buildings. The designers of the Passive Commercial Program recognized that design tool and performance data on occupied buildings was needed before passive strategies would be readily accepted by the design community. The program, therefore, was designed to meet these needs. Approximately twenty buildings are being monitored for energy performance. The data will be analyzed by architectural and engineering experts, so that the design community can understand the more successful aspects of this program and then apply them in their everyday practices.

This program has recruited architects and engineers and allowed them to tell DOE how to develop design tools that would facilitate the adoption of passive solar strategies. Consequently, the analytical techniques that result from this program will better fit the needs of the building designers.

The Residential Program

According to the National Association of Home Builders (NAHB) this program has been successful because it has recognized the industry's diversity. Working with NAHB and its building sector colleagues, DOE has set the program's agenda on the basis of the input it received from the practitioners of the building trades.

An example of but one of the successes of the program is the "Denver Metro Project." Through the asupices of DOE headquarters and the Solar Energy Research Institute builders and designers were brought together. The result of this cooperation was production of energy efficient residential designs. Exposure of the project's results to the broader consumer and contractor community has resulted in the widespread incorporation of passive solar principles in many of the homes constructed in the Denver area.

During the first session of the 97th Congress, the building industry informed the committees of both the Senate and House that the issue of how money was spent was significantly more important than how much money was ultimately appropriated. As an industry in the shadow of its 40th month of recession we are responsive to the call to reduce unnecessary government expenditures and borrowing. We believe, however, that passive solar technology is a good national investment and that it is possible to fashion an important if diminished federal program without doing violence to the FY '83 budget. Federal and industry resources which are carefully balanced between near and long-term targets of opportunity will assure the continued development and application of passive technology on buildings and serve to both save energy and stimulate economic activity. It is the passive solar industry's belief that Mr. Coolidge was right and that the business of government is business. Through the combined efforts of industry and government Americans can have affordable and efficient housing.

Finally, a note of concern. Over the past months it has become increasingly clear that the Department of Energy has chosen to phase out passive solar programming. The act is both presumptuous and wasteful. Because of the Department's decision, FY '82 funds are being spent to phase out the program. The Congressional appropriation was to be used for continuation, and not termination, of the passive solar effort. Such activities as the transfer of technical information between the research and applications communities have been de-emphasized and their resources re-directed into long-term research. The problem is further compounded by the reduction in passive program personnel and the management difficulties associated with an ever changing re-organization.

The industry still needs to know and the material generated by government programs provides an invaluable source for that information. Balance must be maintained between long-term research and near-term activities necessary for the continued application of passive solar technology. Such activities include systems performance testing, design tool development and integrated systems designs. The industry also requires stability in government programming. To avoid the phase-out mentality exhibited by the Department this year we recommend that provision be made in the legislation governing the FY '83 authorizations and appropriations which takes the program monies not spent during one fiscal year and carried them forward in each succeeding year until expended as proscribed by law or formally rescinded or deferred. Further, these carry-over funds shall not be used to supplant the new year's spending authority.

Mr. Chairman, members of the committee, thank you. With the mutual cooperation of the government and industry partners it is possible to develop energy efficient structures and to stimulate investment and productivity within the emerging solar market.

This concludes my remarks.

THE BUILDING ENERGY RESEARCH PROGRAM

AN INTEGRATED APPROACH TO FEDERAL RESEARCH ON BUILDING ENERGY USE

APRIL, 1982

Developed through the cooperative efforts of representatives of the following groups:

American Council for an Energy-Efficient Economy
American Institute of Architects
Brick Institute of America
Building Energy Design Tool Council
Building Owners and Managers Association International
Energy Conservation Coalition
Environmental Policy Institute
Federation of American Scientists
International Union of Bricklayers and Allied Craftsmen
National Association of Home Builders
National Association of Home Builders Research Foundation
National Home Improvement Council
Northeast Retail Lumbermen's Council
Passive Solar Industries Council
Solar Energy Industries Association
Solar Lobby

BUILDING ENERGY RESEARCH PROGRAM

SUMMARY

A number of groups, representing the buildings sector and public interest concerns, are proposing the establishment of a comprehensive and integrated Building Energy Research Program. This program would consolidate the three primary federal research and development efforts concerned with buildings-related energy technologies: the Buildings and Community Systems Energy Conservation Program and the Active and Passive Solar Heating and Cooling Programs. Combining these elements into one program will permit more efficient usage of the very limited federal funds available for building energy research. And, perhaps more importantly, it will facilitate the examination of buildings as dynamic, integrated energy systems.

A comprehensive building energy research program is essential, because buildings use over a third of the nation's energy. To date, a number of federal programs have helped the nation's building industries make progress in developing ways to reduce the consumption of energy in this sector. But these programs have been organized around individual technologies, rather than in a coordinated approach to improve the overall energy efficiency of buildings. Similarly, these programs have placed insufficient emphasis on meeting the technical and informational needs of the individuals, organizations and businesses that actually construct and use buildings.

Despite these problems, progress has been made. Expertise has been developed on how to audit residential buildings for the efficiency of their energy use. Active and passive solar technologies are evolving, which permit dramatic reductions in the use of conventional energy in buildings. New, more energy-efficient products have been successfully tested and introduced for commercial application. These steps have happened as a result of federally-sponsored research and development.

An examination of the buildings sector reveals why, in addition to its potential for energy savings, a federally-supported energy use research program is needed. The building industry is decentralized, predominantly made up of many small-to-medium-sized firms involved in building construction or in the distribution of systems and components that go into buildings. This makes it very difficult for the industry to undertake a comprehensive energy research program. Building users are likewise very diverse, including major public and private institutions, small businesses, and individual owners and renters of single family homes and apartments. A coordinated federal research program is essential to address this wide range of interests in a meaningful way and to continue the nation's progress toward real energy efficiency in buildings.

The proposed Building Energy Research Program is an integrated and comprehensive approach to energy research which meets the needs of both building owners and occupants to reduce energy comsumption and of the building industry to develop cost-effective approaches to reducing conventional energy use. Key aspects of the proposal are:

1. Buildings should be treated as integrated and dynamic energy-using systems. This approach recognizes that greater energy efficiency can be attained by appropriate coordination of various energy technologies and components within a building or between a building and a larger community-scale system or utility grid. This approach also departs from the more traditional consideration of energy conservation and active and passive solar as separate technologies.

2. The Research program should be based upon the actual behavior of occupied buildings. Once again. this represents a departure from the present programs, which mainly model the behavior of occupied buildings on computers rather than gathering empirical data on them.

3. Residential and commercial buildings should be treated separately. These buildings have different design and construction techniques, different types of energy systems, and different use patterns. Research should be structured to recognize these differences. Moreover, within each of these categories, existing buildings are treated separately from new buildings, once again because the techniques involved in retrofit applications are quite different from those in new construction. (It is important to note here that, although it is much easier to incorporate energy efficiency improvements into new buildings, the potential for overall energy savings is much greater through the upgrading of the stock of existing buildings.) Finally, multi-family buildings are recognized as a unique problem in both the residential and commercial categories.

4. The research program should be oriented toward the specific needs of those who will apply the research results, namely homebuilders, architects, engineers, appliance and product manufacturers, retrofitters, building owners and occupants. This has not been sufficiently true of the existing programs. To provide the proper orientation, this proposal calls for the direct involvement of the various members of the buildings sector in the planning and direction of the research program. This kind of partnership can ensure that the resources for energy research of the federal government and of industry will be used

most efficiently. It is important to note that considerable data on building energy technologies has been developed through the existing research programs. Even though we are suggesting the redirection of these programs, this data remains valuable, and deserves continued analysis and application within the proposed program.

5. The research program is balanced between near and long-term development work. It is unrealistic to consider that all the federal government needs to support in this area is basic research. The most promising research in the buildings sector -- with respect to energy savings -- lies with nearer-term developments. But the nature of the buildings industry, as was described, makes sole support for them by the industry as difficult as support for long-term research. As in the past, however, the industry will continue to lend its resources where appropriate to the application of technologies and strategies developed through the proposed program.

6. An ongoing component of the program should be research into the health and safety aspects of building energy systems. Recent problems with the indoor air quality of super-insulated structures suggest that attention should be given to potentially adverse side effects of new energy systems and design strategies. This kind of research is most appropriate for the federal government, which is charged with protecting the public health and safety.

The groups that have worked together to outline the Building Energy Research Program are convinced that a tightly-managed research effort can achieve substantial results if funded at a level roughly equal to the sum of funding levels authorized by Congress for fiscal year 1982 operations of the Active and Passive Solar Programs and the Buildings and Community Systems Program. We are convinced that such an investment is essential if the nation is to realize the enormous energy savings possible through improvement of the existing stock of buildings constructed when energy prices were low. We are also convinced of the importance of achieving even higher efficiencies in new buildings. While each of the representative groups might emphasize different specific needs within the research program, we all strongly support the concept of an integrated national program.

PROGRAM SCOPE

For each area of concern (residential, commercial, new and existing) the Buildings Energy Research Program should support the following types of work:

BASIC RESEARCH

Research on materials, components, and concepts fundamental to energy-efficient buildings.

APPLIED RESEARCH

Research Integration - integration of basic research elements into buildings and energy systems, and monitoring and evaluation of their performance in occupied buildings to produce an accurate understanding of energy-conserving strategies.

Prototype Development - development of systems, components and building techniques that can be used to implement energy-conserving strategies in cost-effective ways.

Institutional Research - analysis of institutional barriers that impede development and utilitzation of energy-efficient techniques in buildings, and assessment of ways to mitigate them.

TECHNOLOGY TRANSFER AND INFORMATION DISSEMINATION - packaging of program results (information on products, components, systems and innovative institutional approaches) in forms useful to the individuals, organizations and businesses that are involved in the design, construction, purchase and use of buildings (including demonstrations to prove the feasibility of innovative building products, techniques and institutional approaches).

RESEARCH NEEDS

The following is a list of important research needs in the residential and commercial buildings sector, for both new and existing stock. It is not comprehensive; it is intended to show some areas of priority.

RESIDENTIAL BUILDINGS - NEW

Basic Research

- Thermal load dynamics within buildings.
- New thermal storage and glazing materials.
- Building environmental quality (e.g. indoor air quality).
- Building materials and system controls.
- Research leading to high-efficiency appliances.
- Research leading to high-efficiency heating and cooling systems.

Applied Research

- Collection of data on thermal behavior of occupied buildings.
- Integration of solar systems with conventional heating and cooling systems.
- Collection of cost and performance data on integrated systems in various climatic regions.
- Assessment of the impact of energy efficient buildings on utility load management.
- New technologies for community-scale systems.
- Prototype development of thermal storage and building envelope materials and components, active and passive solar systems.
- Documentation and analysis of institutional decision making processes which affect the development and adoption of energy conserving strategies by end users (financial institutions, buildings owners, state and local governments).

Technology Transfer and Information Dissemination

- For homebuilders and construction trades (e.g. design innovations and construction techniques).
- For product manufactuers (e.g. performance data).
- For financial institutions (e.g. impact of energy systems and strategies on capital and operating costs).

- For building owners and occupants (e.g. operating costs).
- For local governments and utilities (e.g. innovative institutional approaches).

RESIDENTIAL BUILDINGS - EXISTING

Much of the necessary research is similar to that needed for new residential buildings. There is, however, an additional need to address the following:

Basic Research

- New retrofit materials.
- Cost-effective retrofit techniques to mitigate infiltration and conduction losses.

Applied Research

- Collection of cost and performance data on buildings before and after retrofit.
- Prototype development of packaged retrofit systems.
- Analysis of how relationships between building owners and renters affect energy decisions.

Technology Transfer and Information Dissemination

- For home owners, product and system distributors and remodelling contractors -- a much more dispersed set of industries than those involved with new buildings (e.g. retrofit manuals).
- Information on innovative delivery systems for local governments and utilities (e.g. one-stop-shop energy programs).

COMMERCIAL BUILDINGS - NEW

Basic Research

- New building shell and glazing materials (e.g. to reduce night heat loss).
- Building environmental quality (e.g. indoor air quality).
- Advanced lighting and HVAC systems and controls.
- Heat recovery systems.

Applied Research

- Analysis of energy dynamics and control strategies for complex, multi-zone buildings.
- Assessment of interrelationships between active and passive heating and cooling systems (and daylighting), and their integration with conventional systems, according to various building types and climatic regions.
- Collection of cost and performance data by building type and climatic region.
- Prototype development of HVAC systems - (e.g. for individual building zones), lighting systems and strategies, heat recovery systems, and glazing systems.
- Assessment of financial and institutional factors affecting energy decisions by building owners (including concerns of financiers and occupants).

Technology Transfer and Information Dissemination

- For architects, engineers and developers (e.g. design and analysis tools that accurately predict building performance).
- For financial institutions (e.g. impact of energy systems and strategies on capital and operating costs).
- For building owners and occupants (e.g. operating costs).
- For product manufacturers (e.g. performance data).
- For local governments and utilities (e.g. innovative institutional approaches).

COMMERCIAL BUILDINGS - EXISTING

Much of the necessary research is similar to that needed for new commercial buildings. There is, however, an additional need to address the following:

APPLIED RESEARCH

- Monitoring performance of buildings before and after retrofit.
- Improvement of operating efficiency of existing systems (e.g. through improved maintenance).

- Development of more efficient HVAC and lighting retrofit strategies, and of smaller, more efficient prototype replacement systems.

- Development of energy retrofit techniques that meet other rehabilitation requirements (e.g. for fire protection, structural integrity and building safety, among others).

- Analysis of how relationships between building owners and occupants affect energy decisions.

Technology Transfer and Information Dissemination

- For architects and engineers (e.g. cost and performance data on retrofit strategies).

- For product manufacturers (e.g. product performance data).

- For utilities, local governments and energy management companies (e.g. innovative institutional approaches).

Senator **Ford** [presiding]. Thank you, Mr. Stronberg. I believe the chairman would like to be in the posture of submitting written questions to each of you and asks that you respond as soon as possible. I will try to ask a question or two based on the testimony given by each of you very briefly.

Dr. Lawrence, I will start with you. What do you believe the fuel economy of the advanced Stirling engine will be in comparison with the internal combustion engine for the same usable horsepower?

Dr. **Lawrence**. The Mod II engine, which is the one that would be done in the United States completely, based on our present design is depicted as an average number, because it depends on the size of the car and all kinds of things, on the order of 50-percent improvement in fuel economy.

The numbers actually range between 42 and 52. It is on the order of 50 percent improvement over internal combustion spark emission.

Senator **Ford**. How about the cost comparison of the two engines?

Dr. **Lawrence**. At the moment we have done an extensive, we actually contracted out the people who do this, an extensive manufacturing cost study on the engine. It is now projected to be about twice the cost in manufacturing of the internal combustion engine. It is a little higher than the present diesel engine would be. We do have a manufacturing cost reduction as part of this program and that should bring it down in the next year or so to the projected diesel manufacturing cost.

Senator **Ford**. The same manufacturing cost as the present diesel engine?

Dr. **Lawrence**. Yes, sir.

Senator **Ford**. How interested is the auto industry in changing to this type of engine?

Dr. **Lawrence**. It differs from company to company. I believe we still have a way to go before we look at it as something that they would want in the next couple of years to put in their cars. We are not quite that far ahead. American Motors has been very supportive of us and is quite enthusiastic about the technology.

Ford Motor Co. has been monitoring the program closely and although at the moment they have chosen the turbine direction to go, we understand that Ford has made some significant supportive statements about our program recently.

General Motors in the late 1960's attempted to work with Stirling technology and they made a corporate decision in 1970 to reject it. They have not changed that decision.

Chrysler, we have initiated a conversation with. Since they are now buying most of their engines overseas, they look like they could be an attractive early customer for the engine.

Senator **Ford**. Mr. Washom, will you provide for the committee the funding for each solar thermal demonstration project on a year-by-year basis to achieve an orderly phase-out of Federal support? Can you do that?

Mr. **Washom**. Yes, sir.

Senator **Ford**. How long do you think it will be before we can have those figures?

Mr. **Washom**. That would not be difficult to achieve. I would say within 10 days we could do that. Appendix A of the prepared testimony outlines the fiscal year 1983 request. So your request only really requires us to look at the out years as well, which I think we have done, but not presented in the testimony.

Senator **Ford**. By reading your testimony, I felt that you could. That is the reason I asked if you could present that for us. I think it is important. I asked the question earlier of what the benefits up to today have been, and one of the witnesses elaborated on things that were happening, what they were into, and what they expected in the next 5 to 8 years.

I think it is essential that the Government perform as best they can in the commercial operation, and let it move into the competitive market.

Mr. **Washom**. I might point out that in the out years, we have in essence weaned one of our technologies now as being parabolic trough industry from the budget.

Senator **Ford**. How difficult was it to wean?

Mr. **Washom**. It was, I don't want to say a little premature, but it was a forced decision by foreign competition, who came in here on a subsidized basis where American industry either had to bite the bullet and make a very large corporate investment and sign capital commitments and performances to new customers in the venture capital community or to completely give the market away to the foreign competition.

In the other areas of the central receiver and the parabolic dish program, we are witnessing as we approach this system applications area, better known as demonstrations in the past, that there is a level of cost sharing, as much as 50 percent and this is where the largest pressure on the burden is placed is when you get to the demonstration phase.

So we are trying to reduce the Federal budget by assuming a larger role in the cost sharing cooperative agreements that are available to us.

Senator **Ford**. If you assume a larger share, I take it that comes from the consumer basically.

Mr. **Washom**. No, sir. This basically comes from private investment.

Senator **Ford**. Where does the private investor get their money?

Mr. **Washom**. This is risk capital.

Senator **Ford**. Risk capital is allocated from the budget. Basically it comes from the consumer and so much of that is put into risk capital or whatever. Then when you get into that arena, the benefit ratio back to the consumer is the important factor. Is it not?

Mr. **Washom**. That is right. The whole time, in our case in the solar thermal field, neither the taxpayer nor the rate payer in the solar thermal electric is really "at risk" if we should fail technically or economically.

Senator **Ford**. You take it out of dividends to your stockholders.

Mr. **Washom**. Let us use my company as an example. We are in the process of signing a competitive procurement where the DOE portion is $2.9 million and we are cost sharing $850,000 and that is coming out of bottom line profit. I might add we are a very small business.

Senator **Ford**. If it is all operated efficiently and the economy improves, you will be able to do that. Otherwise, you are not going to be able to continue.

Mr. **Washom**. That is correct.

Senator **Ford**. Mr. Enfield, have you prepared a set of increases in solar R&D which would constitute an adequate program for fiscal year 1983?

Mr. **Enfield**. I would not use the term increases. We have basically followed this committee's early lead in supporting continuation of 1982 levels.

Senator **Ford**. Let me rephrase that to increases in the administration's proposal.

Mr. **Enfield**. Yes. That is what we are working on right now and I suggest that in a couple of weeks, I would like to submit it for the record and to the individual offices. And essentially it is at the 1982 level, continued into the 1983 program. I think it is adequate. I don't think there is a lot of fat in it.

Senator **Ford**. I do not think so either. Will you provide that for the committee? Would you do one other thing for me? Would you be willing to put it in priority? That stings a little bit, doesn't it? Of course you just get paid for representing. I have to put them in priority on occasion. If you get to the point where you can put it in priority, I would appreciate it very much.

Mr. **Enfield**. Certainly, sir.

Senator **Ford**. Mr. Casazza, does your institute support reductions in the other end of the R&D programs that provide the funds for increases in conservation and renewable resources R&D?

Mr. **Casazza**. I think what we are saying, Senator, is not what the total amount should be for R&D. I think that you are in a far better position to set that total. If the total is as it now is in the budget, you have not given a sufficient amount to the solar and conservation areas.

To answer your question a little more directly, if the total cannot be increased for R&D, yes, we are saying some reallocation to lower in some other areas to increase in this area would be justified.

Senator **Ford**. We found that testimony in an earlier panel. They preferred we reduce yours and increase theirs. That makes our problem a little more difficult.

Mr. **Casazza**. We, as electrical engineers, are not advocates of any particular technology. We see this national problem to keep this balance and keep this diversity, because God knows, none of us know what the future holds for this country in the energy area and we want to stand ready for the various uncertainties.

Senator **Ford**. The Lord only knows.

Mr. **Casazza**. Senator, I would like to add, I did not think of it when Senator Domenici asked me, we have our pamphlet here giving our overall views of the long-range energy picture, which answers and provide data in a number of question areas that you have asked for information on. I wonder if it would be possible to enter it into the record.

Senator **Ford**. We will have that entered into the record.

[The pamphlet follows:]

What other groups provide information on energy?

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For Further Information
Contact:

IEEE
United States Activities Board
1111 19th Street, N.W.
Washington, D.C. 20036 (202) 785-0017

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ENERGY

A slide presentation of the Energy Committee of the Institute of Electrical and Electronics Engineers, Inc.

ENERGY IN PERSPECTIVE

Introduction

This presentation puts the U.S. energy problem in perspective. First, we examine causes and means of correcting them. We consider existing and new energy sources available to us, and how we can meet our needs, particularly in the critical period between now and the year 2000. Finally, we suggest ways that you as an individual, can help remedy the problem.

Where are we now?

The world's population exceeds 4 billion people and will likely be over 6 billion by the year 2000. And, we are all dependent on the earth's finite resources. In these circumstances, it is essential that our resources be treated with utmost care and that technology be developed to permit an improved quality of life, especially for those who now live in deprivation.

We are experiencing the beginning of an energy crisis of global dimensions. For the past 30 years, liquid petroleum has fueled the tremendous economic growth in the industrialized countries, and today, about 45% of the world's demand for energy is being met with liquid petroleum. Because the United States consumes 27% of the world's total annual production of liquid petroleum, much of the world considers America responsible for global energy shortages.

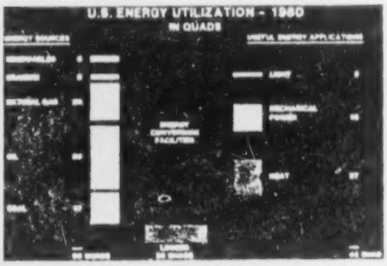
How much energy do we consume? Where does it come from?

This chart shows the U.S. energy supply picture, by fuel types, with sources listed along the left side. Energy demand is also shown, by applications listed along the right side. Of our total usage of 80 Quads* in 1980, 5 came from renewable resources (hydropower, solar, biomass, and others), 3 from uranium, 20 from natural gas, 35 from oil — our primary fuel — and 17 from coal.

On the demand side, 2 Quads were consumed for lighting, 15 for all types of mechanical power — including transportation — and 27 for heating, which amounts to 44 Quads. Losses, or the energy consumed in converting our resources to useful applications, accounted for 36 Quads, or 45% of total production.

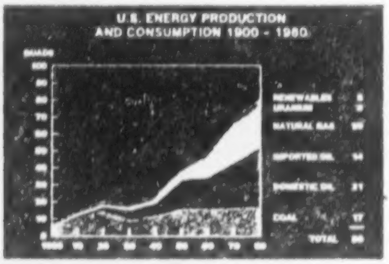
You can see that 90% — 72 Quads — is derived from non-renewable hydrocarbon resources: oil, natural gas, and coal. Nearly half of those 72 Quads come from a single source: oil.

U.S. dependence on foreign oil supplies has already played havoc with our inflation rates, unemployment levels, foreign affairs and trade relations. Clearly, we must move as a nation to diversify our sources of energy, if we are to minimize the effects of supply disruptions — such as we experienced during recent mideast oil cutbacks — and hold down spiraling costs of these non-renewable resources.



How has our national demand for energy grown?

Additional problems arise when we consider our nation's increasing demand for energy. This chart shows the increases in demand during this century. In 1900, our nation's total energy consumption was only 9 Quads. By 1950, it had more than quadrupled to 40 Quads a year. Today we use 80 Quads. Are we on a trend that quadruples energy consumption every 50 years?



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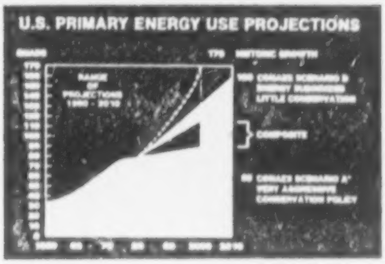
*A Quad is a quadrillion British Thermal Units (10^{15} Btu). One British Thermal Unit is the amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit.

Certainly this pace of growth cannot be kept up for long without running into all kinds of constraints, as we are already experiencing.

What about the future?

Despite vigorous conservation, demand for energy is still expected to grow. Many studies have been made to predict the levels of energy demand and domestic supply through the year 2000. A comprehensive study was published by CONAES, the Committee on Nuclear and Alternative Energy Sources of the National Research Council. Projections range from 70 Quads to 170 Quads, depending upon assumptions made about population growth, economic growth, and changes in the relationship between energy and economic activity.



Conservation measures effected as a result of skyrocketing oil prices are already having a dramatic effect on this relationship. Nonetheless, most widely accepted projections, from this study and others indicate a requirement of between 90 and 110 Quads for the year 2000.

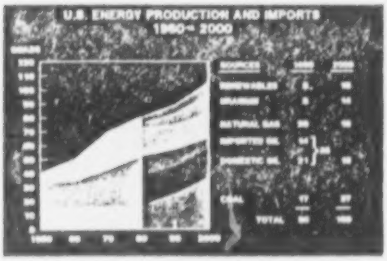
How can we solve the problem?

America's energy problem is really three problems requiring creative solutions. First, we must diversify our energy sources, in order to reduce the impact of supply disruptions. Second, we must contain the growth of our overall energy consumption. Third, we must achieve the first two objectives in a way that will allow healthy economic expansion and improvement in our standard of living.

Will we have enough energy by the year 2000?

U.S. energy production is expected to look very different in 2000, compared to today. Coal, uranium and renewable resources are all going to make significantly greater contributions, and coal will again become our dominant fuel. Domestic oil and gas production will remain fairly constant and decrease as a percentage of our overall supply.

If we are successful in limiting energy demand to 100 Quads by the year 2000, then it is even possible that our dependence on imported oil can be eliminated.



Can we limit energy demand while improving our standard of living?

The answer to this question depends entirely on our willingness to develop our domestic energy resources vigorously, and on our ability to conserve energy.

The idea of conservation is not merely to cut down our use of energy, but to eliminate waste and improve the energy efficiency of our industry. This will help to reduce — but cannot fully eliminate — the 36 Quad losses pointed out earlier.

How can we conserve energy?

Improvements in conservation can be made in:

- Private and Public Transportation
- Private Housing
- Industrial Facilities
- Scrap Recycling
- Solid Waste Utilization

Clearly, some of these are areas where you, as an individual, can make an impact.

Automobiles remain one of the least efficient forms of energy use. Despite rises in gasoline prices, the U.S. still consumes about 49% of world supply. Many communities encourage carpooling by helping you to contact commuters in your neighborhood, or by reserving roadways for carpoolers in rush hours. Mass transit can be a more efficient and economical alternative to automobiles. Railroad systems should be electrified wherever economical, as another step to reduce our reliance on oil fuels.

Among the alternatives for private transportation in the near future will be electric vehicles. Additional development of lighter, more efficient batteries is needed, however.

Adding insulation to your home, or a heat pump, can result in immediate savings of both energy and money, and can also result in tax credits.

More efficient use of household appliances and lighting can also yield savings, without any loss in the high standard of living Americans now enjoy. When purchasing major appliances, check the energy usage tags that tell how much energy they consume and how much they cost to operate.

Passive solar heating, which depends on proper construction and orientation of buildings, could yield important savings. Many homes and buildings are being fitted with solar greenhouses, in addition to roof-top collectors, to reduce their energy requirements.

Scrap materials must be recycled to a greater degree. Aluminum, for example, can be recycled for 5% of the energy it takes to produce the same amount from bauxite, the primary aluminum ore.

Another way to eliminate waste in industry is through a technique called cogeneration. As an example, heat exhaust from industrial processes can be used sequentially, at progressively lower temperatures, to provide a multitude of uses.

Electricity generation utilizes a large part of our raw resources and accounts for about half of our 36 Quad conversion losses. Much of the generating equipment was built when the cost of more efficient designs outweighed fuel savings. To reduce these losses, heavy investment in new equipment must be made, and research into advanced techniques and machinery must be continued.

What else must we do?

We have great challenges ahead. U.S. coal production must double by 2000, which will require the opening of hundreds of new mines and doubling the workforce of 250,000 miners. Heavy equipment and coal cars will have to be manufactured. Barges and pipelines will have to be built. Coal is expected to provide an additional 20 Quads.

We must build 50 more nuclear power plants than we have operating or on order today. Because of the lead-time necessary for construction, the last of these 50 must be ordered by about 1990, if it is to be in operation by 2000. These plants could provide 11 more Quads.

The savings estimates for passive solar and heat pumps require that all new housing constructed between now and 2000 come equipped with these technological improvements. This would provide up to 7 more Quads.

In order for wind power to provide 1 Quad, we must have 35,000 turbines in operation by 2000.

How can we do all that?

We must become more knowledgeable about energy issues and talk to others about them. We should be active in our communities, with our civic organizations and our schools, as well as at the state and national levels. We need to encourage our state and federal governments to support research and development into those technologies that will serve our energy needs between now and 2000, and other technologies that we might rely on through the next century.

Now is the time to get involved and speak up!

What is IEEE doing?

IEEE has studied many research opportunities and challenges confronting us and developed positions that it has presented before Congress and the U.S. Dept. of Energy. Some of these concern the need for electricity, conservation, solar energy, fusion, and nuclear power. These positions can be obtained from the IEEE Washington Office. This office has information that can help you to present the facts on energy programs and discuss them with others in your community or at your workplace. The staff can help you get in touch with other information sources at the local, state and national levels.

Mr. **Casazza**. Thank you.

Senator **Ford**. Mr. Stronberg, I don't have any questions for you, but I have sympathy for your position.

Mr. **Stronberg**. From your mouth to the President's ears.

Senator **Ford**. We have found that we have been like a yo-yo in the last 10 years in this country with regard to energy, and when we have a shortage we really get concerned. All of a sudden, when there is no shortage, we relax. When there is another shortage, we just jump and try to put all the money into it.

What you do is you have a team onboard and you move forward. All of a sudden the funds are diluted and the team is gone. It is difficult to get that team back together or a similar team to keep it going. We are just absolutely screwing up the energy program in this country every day.

So I can understand your frustration in saying, we are not the greatest association of expertise, but you are a large industry that has the ability to make a contribution. As I mentioned earlier, we now find OPEC turning the spigot off and reducing their production. The 2 million barrels a day, which is 2 percent of the daily international consumption, turns from a producer's market to a buyer's market. They turn it off a little bit, and then it becomes a seller's market.

So we need to be consistent and move forward. I think we are going to have to, at some point, make some decisions on what is best and begin to fund those decisions rapidly. We are going to develop some white elephants. We are absolutely going to fund some white elephants. I think we ought to get about the business of funding white elephants to find out whether it works or whether it does not.

And then when it does not work, we will move on to something else. I have been here 7 years now, going on 8, and when I came here there was not an energy committee. We finally got one to sit down and think and talk purely and simply energy. We, I believe, find the thinking on this committee is consistent, but we find in this country it moves from relaxation to concern.

So with that little to-do, we will do this: There may be other members of the committee that will have questions, and we will submit those to you in writing. Hopefully you will respond in a reasonable length of time. The information I have asked for from at least two of you here, if you could get that to us within the next 10 days or 2 weeks, I would be grateful to you.

So I will recess the committee hearing, subject to the call of the Chair, and I thank all of you.

[Whereupon, at 11:45 a.m., the hearing was adjourned, subject to the call of the Chair.]

APPENDIX IV

ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD

The American Physical Society

Division of Nuclear Physics

G. T. Garvey, *Chairman*
Physics Division
Argonne National Laboratory
Argonne, Illinois 60439

S. M. Austin, *Vice Chairman*
Cyclotron Laboratory
Michigan State University
East Lansing, Michigan 48824

J. A. Harvey, *Secretary-Treasurer*
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

April 16, 1982

The Honorable Pete V. Domenici, Chairman
Subcommittee on Energy Research and Development
United States Senate
4239 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Domenici:

As the present Chairman of the Division of Nuclear Physics of the American Physical Society I would like to express my personal opinion regarding the FY 1983 budget submission of the Department of Energy for basic research in Nuclear Physics. This submission was part of the DOE request in Basic Science, the Nuclear Physics component can be tabulated as follows:

	Appropriation		(Request)
	FY 1981 (MS)	FY 1982	FY 1983
Medium-Energy Physics	46.000	50.600	53.100
Heavy-Ion Nuclear Physics	39.060	41.814	39.700
Low-Energy Nuclear Physics	11.582	12.257	12.400
Nuclear Theory	7.000	7.700	8.150
Capital Equipment	9.870	9.510	9.900
Construction*	4.400	7.500	7.700
	117.912	129.381	130.950

Note that the requested increase for FY 1983 is only 1.2% above FY 1982. By any reasonable calculation this implies a substantial reduction in spending power. This action will lead to a reduction of 50-100 trained scientific personnel involved in U. S. Nuclear Physics. In many cases this will represent the loss of years of special training at great cost to the Federal government. The reduced support requested for Nuclear Physics stands in marked contrast to the Department's request in all other areas of Physical Science. For example, in High Energy Physics the requested increase for

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*The construction budget is shown with the M.S.U. system which was transferred to N.S.F. for FY 1983 taken out of FY 1981 and FY 1982 to allow a direct base of comparison.

FY 1983 is 17.8% above FY 1982. As the DOE provides the principal support for both Nuclear Physics (80%) and High Energy Physics it has had a "National Trust" to see that these areas of research are kept appropriately healthy. The Department's backing away from the support of Nuclear Physics must be regarded as a science policy decision for the United States. Absolutely no discussion of this serious matter occurs in Dr. Trivelpiece's testimony to the House Appropriations Subcommittee on Energy and Water Development, March 4, 1982.

By way of further information, the requested increase in Basic Energy Science (BES), the other component of DOE Physical Research for FY 1983, is 16% above FY 1982. I strongly support these requested increases in other areas of physical science but I am at a total loss to comprehend the Department's requested cutback in Nuclear Physics. I believe it must simply be an error. Close examination of the DOE FY 1983 budget submission and Dr. Trivelpiece's testimony further strengthens this impression. Heavy-ion research is the area wherein the newest nuclear research facilities are coming into operation. The Holifield Lab at Oak Ridge National Laboratory and the Superconducting Linac-Booster at the Argonne National Laboratory will be coming into operation as User facilities in FY 1983. Both of these installations are burdened with effectively reduced budgets, presumably because of the proposed 5.1% reduction for Heavy Ion Research.

It is at the very least extremely wasteful not to capitalize on the investment so recently put into the construction of these facilities. As a researcher, it appears scientifically indefensible to build new facilities without even a pretense of trying to effectively utilize their scientific potential.

I have every confidence that your Committee recognizes the importance of basic research and the important rôle that nuclear physics plays within it. In FY 1982 the Congress played an essential role in minimizing the disastrous effects of the 12% reduction requested by the Administration. I believe that this showed an awareness of the importance you accord basic research.

Lest you believe that nuclear physics may have enjoyed real growth over the past decade let me dissuade you of that immediately. Enclosure Number I shows the annual budget for U. S. Nuclear Physics over the past 20 years. Our current rate of expenditure is at best comparable to that of the middle sixties. Presently Western Europe and Japan are investing vastly more resources in basic nuclear research than is the U.S.--and the gap grows yearly. Germany alone invests more resources in nuclear research than does the U.S. In terms relative to the G.N.P. the gap is a factor of 3 more as Enclosure II shows.

The leadership position that the U. S. enjoys is a tribute to the flexibility and intelligence of the U. S. scientific community. However, nuclear research facilities are now becoming available in Europe that we simply will not be able to match. You must begin to think in terms of not only rectifying the mistake of the DOE for this fiscal year but actively seeing that the Nuclear Science Advisory Committee's long-range plan is implemented over the next decade.

However, let me not dwell solely on the budgetary aspects of Nuclear Physics but take a moment to point out a few of the exciting new developments in this field and look a bit to the future.

Recent research with medium-energy probes, most particularly electrons and protons, produces direct evidence that particles in addition to the neutron and proton must be included in the description of nuclei. Accounting for recently-observed phenomena requires the presence of pi (π) mesons, rho (ρ) mesons and a close cousin to the nucleon, the delta (Δ). These short-lived particles have been known for many years and were believed to play a role in nuclei, but only recently has one been able to view their effects directly and develop theories quantitatively capable of dealing with them. In fact, the effects of the Δ on the probability with which a fast proton striking a nucleus can change into a neutron and flip its spin may be the first direct evidence we have for the role of quark structure of the nucleon in low-energy nuclear dynamics.

Heavy ions are used to form nuclear states which spin rapidly compared to the time it takes for a nucleon to transverse the nucleus. This causes the nuclear motion to be directly coupled to the rotation of the nucleus as a whole. In turn this presents us with an entirely new aspect of nuclear structure in which the single-particle motion is strongly aligned with the nuclear spin. The results are truly beautiful and surprising. With appropriate support, the next 15 to 20 years should see a complete characterization of hadronic matter. This characterization should be sufficiently well founded in fundamental theory that it can confidently be extended to the most extreme conditions of temperature and density found in the Universe.

Our increased understanding of nuclear transitions permits the design of sensitive experiments that can probe conditions in the center of the sun via measurement of the neutrinos emitted from the sun. Who can foretell what use will be made of this knowledge? Will we be able to predict the next ice age? The spinoffs from nuclear physics are too numerous to mention. Perhaps that is why Dr. Trivelpiece did not bother to mention them at any length in his March 4th testimony.

As a simple example of the impact of nuclear research in the private sector let me call to your attention a recent study carried out by the National Academy of Sciences that indicates the medical market for the following radioisotopes is: Technetium-99, over 100 M$/year, Thallium-201, 30 M$/year. Our knowledge of the properties and the production techniques for these radioisotopes are all a spinoff from nuclear research. Radioactive tracers now are used in all phases of physical research, engineering, medicine and industry and their use continues to grow. I do not believe that nuclear science is owed anything for the "spinoffs." They are exactly what society has every right to expect from the pursuit of basic knowledge. These examples simply point out that the payoff is there. However, unless your Committee takes specific action, a budgeting action will take place that will impede our continued advances in the understanding of nuclear phenomena and society will lose the benefits of this pursuit.

I believe that the Nuclear Physics Budget should be increased by about 12%. This would require an additional 15 M$ for FY 1983 over the amount appearing in the DOE budget submission. This would allow fuller utilization of our large facilities and would get the research at the new heavy-ion facilities under way in a effective manner. I would be delighted to provide you with any further information that your Committee feels it requires to consider the appropriate funding level for the DOE Nuclear Physics program.

Very truly yours,

Gerald T. Garvey

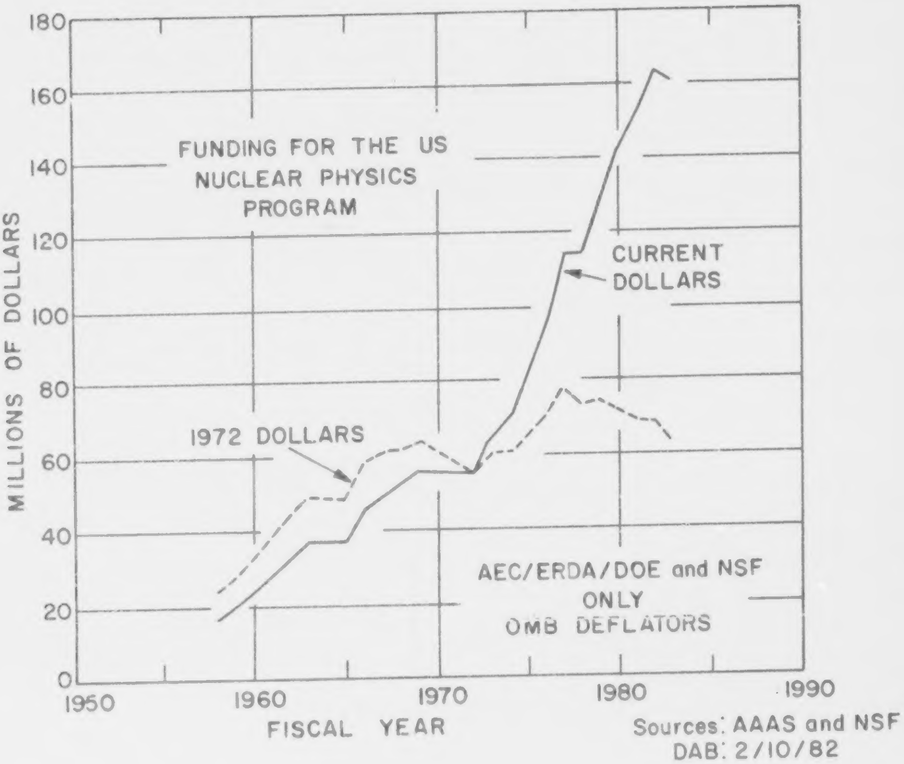
Gerald T. Garvey
Chairman, Division of Nuclear Physics

GTG:kt
Encs.

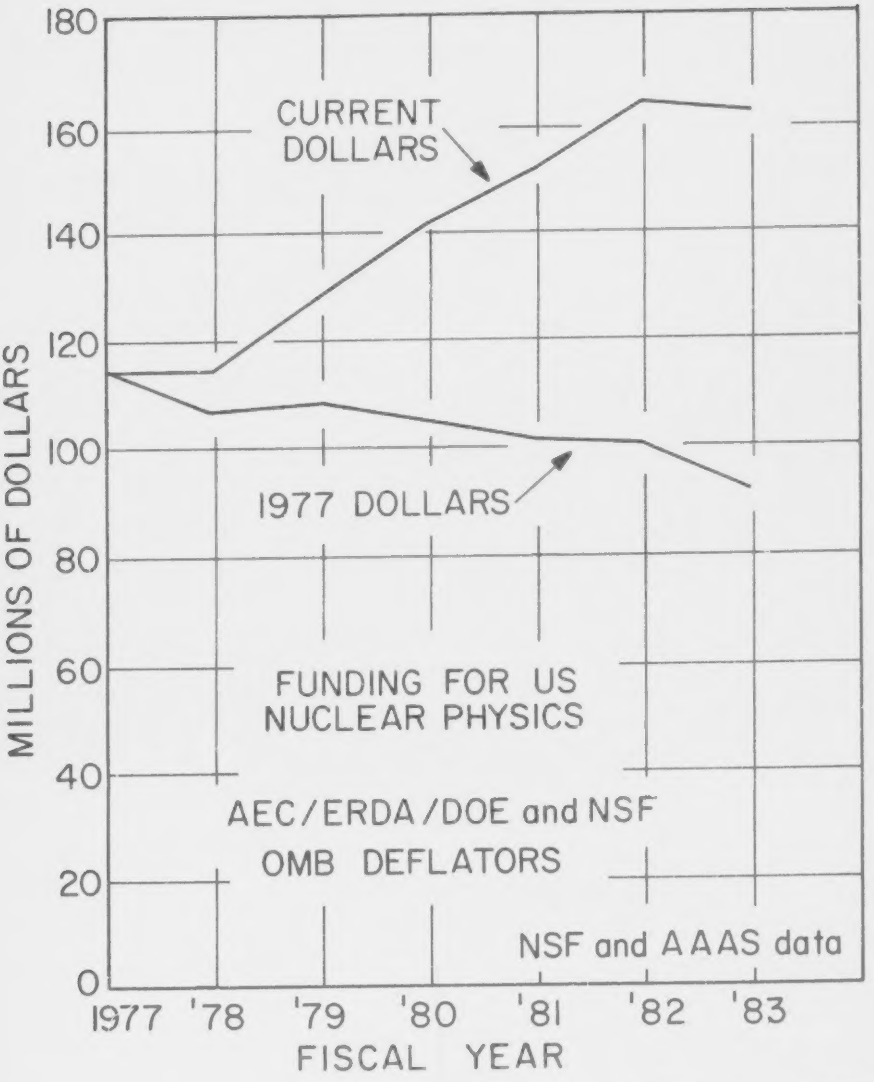
Enclosure #I

The following 3 graphs depict the budgets provided basic nuclear physics in the United States. Basic nuclear science is solely supported by the present DOE and the National Science Foundation.

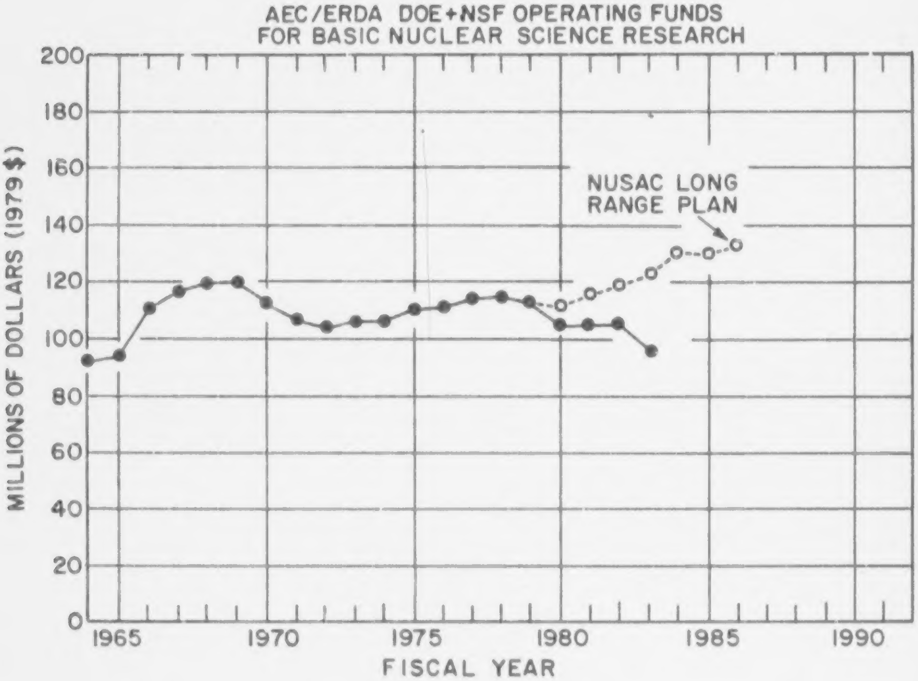
Graph 1	Total support for Basic Nuclear Research in the U.S. in terms of current dollars and in terms of constant 1977 $.
Graph 2	A historic perspective for the support of basic Nuclear Research by the cognizant Federal Agencies. Shown is the budget comparable with a conservative long-range plan drafted in 1979 by a committee (NSAC) advisory to DOE and NSF.
Graph 3	Shows how the effects of inflation over the past 5 years have destroyed any growth in basic Nuclear Physics.



Sources: AAAS and NSF
DAB: 2/10/82


180
160
140
120
100
80
60
40
20
0
MILLIONS OF DOLLARS
1977
'78
'79
'80
'81
'82
'83
FISCAL YEAR
CURRENT DOLLARS
1977 DOLLARS
FUNDING FOR US NUCLEAR PHYSICS
AEC/ERDA/DOE and NSF
OMB DEFLATORS
NSF and AAAS data

DAB: 2/10/82


AEC/ERDA DOE+NSF OPERATING FUNDS
FOR BASIC NUCLEAR SCIENCE RESEARCH
MILLIONS OF DOLLARS (1979 $)
200
180
160
140
120
100
80
60
40
20
0
1965
1970
1975
1980
1985
1990
FISCAL YEAR
NUSAC LONG
RANGE PLAN

Enclosure #II

This is a study carried out in 1979-1980 by the Division of Nuclear Physics of the American Physical Society. It shows:

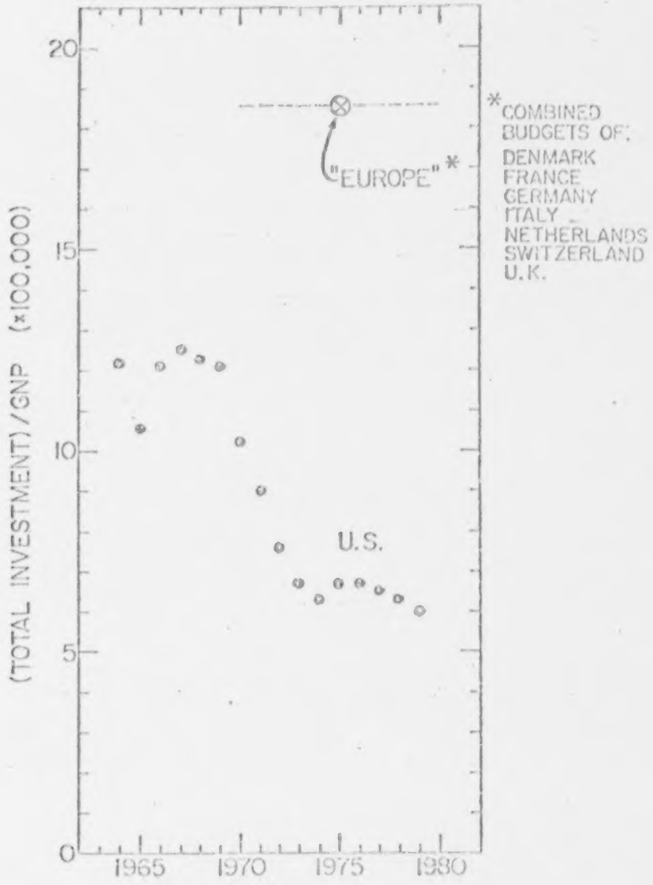
1. Funding for Nuclear Physics in West Germany exceeds the outlay in the United States.
2. France's outlay is 80% that of the United States.
3. Relation to Gross National Product - the ratio is at least a factor of 3 in favor of Western Europe.

INTERNATIONAL ASPECTS OF BASIC RESEARCH IN NUCLEAR PHYSICS

Report of an ad hoc committee of the
Division of Nuclear Physics of the
American Physical Society

Members: P. Axel, W. P. Ewbank, B. G. Harvey, P. Paul, J. P. Schiffer, Chairman

TOTAL NATIONAL INVESTMENT FOR BASIC RESEARCH IN LOW-ENERGY, INTERMEDIATE-ENERGY, AND HEAVY-ION PHYSICS NORMALIZED TO GNP



Introduction

Its natural intellectual drive and curiosity has served the human species generally rather well in its evolution--basic research is a present manifestation of this very human trait. The question of exactly how much of its resources an advanced society should invest in basic research is difficult to answer. But there is very little question that there is a close connection between basic research, technological innovation and the rate at which a society can approach its goals.

The best standard of comparison is perhaps the relative investments in such activities of various advanced societies. Clearly nuclear physics is a relatively small fraction of basic physical research activity but the trends in all disciplines tend to be rather similar.

Procedural History

A subcommittee of the Division of Nuclear Physics of the American Physical Society was appointed in mid-1979. The charge read as follows:

> "To assess and compare the past, present and prospective status of nuclear physics in the U.S. with those in a few selected countries which make major contribution to the advances of nuclear physics, and with which cooperation is likely to be important.
>
> Because of the lack of time, the committee might concentrate its efforts to a few (e.g. two) of the following criteria; available funds, number of investigators and support personnel, facilities, recent contribution, and applications.
>
> The committee should investigate what has been done in the recent past and is presently being done with regard to major international cooperation between other countries and the U.S.
>
> It is expected that the committee complete its work in time to give a written (and oral) report to the Executive Committee of the Division no later than the 1980 Washington D.C. meeting."

In subsequent discussions between Henley and Schiffer it was agreed that the report should focus on the funding patterns and not on the more open-ended questions of facilities and international cooperation. One could envision in-depth comparative case studies of facilities, e.g. LAMPF vs SIN, or SuperHILAC vs UNILAC, that may be worthwhile, but lists of facilities without a more detailed comparison of their funding, staffing, and modes of operation seems of relatively little value. An overall general assessment may be given—but is, of necessity, highly subjective.

Outline of Activities

We undertook to obtain information on three countries for purposes of comparison with the U.S.—France, Germany and Switzerland. Information was obtained for the basic research nuclear physics budgets from the latter two countries, but two independent approaches to get information on the French budget were unsuccessful. The comparison obtained is therefore limited to one between the U.S., Germany, and Switzerland. However, the numerical information for these countries is very similar to the information compiled for the Friedlander Panel four years ago, the research budgets have remained at a more-or-less constant fraction of GNP, and it seems to be a reasonable assumption that the earlier Table retains some current validity.

Recent Funding for Nuclear Research in West Germany

The most recent systematic data on government funding for basic research in nuclear physics and closely allied areas are available from a study prepared and issued by the German Department for Research and Technology,[1] published in 1978. It gives the actual expenditures for the years 1976 until 1978 and contains the official projections for funding until 1981. To make the comparison with the US funding pattern useful the definition of Nuclear Physics is taken here to include all those areas which are generally in the domain of nuclear physics programs at DOE or NSF, i.e. medium energy, nuclear structure, heavy ion physics, and neutron physics. Nuclear solid state physics done at nuclear accelerators and reactors is also given, but was not carried through for comparisons.

Funding for nuclear physics in West Germany basically comes from two sources, the federal government and the state governments. Federal funds typically supply 90% of the operating costs of four large national laboratories (Nuclear Research Center, Karlsruhe, Nuclear Research Facility, Juelich GSI, Darmstadt, Hahn-Meitner Institute, Berlin), provide the German share of the high-flux reactor at Grenoble and the German use of the medium-energy facility in Switzerland (SIN), pays about 50% of the Max-Planck Institut at Heidelberg, and provides support for five major University based accelerators as well as for user operations. The state governments provide the monies for the remaining shares of the large institutions and supports basic research at Universities. State funds included below provide technical support, operating costs of basic research beyond normal academic functions, and capital expenditures for research equipment. Faculty time is counted with 50% toward basic research.

Table I lists separately federal and state expenditures on the various subareas of nuclear physics for the years 1976 until 1978, and the projections for the years 1979 until 1981, from the long-range plan of the West German government. Because of the large yearly fluctuations in the $/DM ratio it is not useful to express these numbers in dollars year by year. The rate of inflation has been about 3% per year until 1979, and is currently around 5.5%. Thus the projected budget increases from year to year exceed current inflation.

In 1975 the number of scientists engaged in basic research in medium energy, nuclear structure and heavy ion physics in West Germany was given as 818. General indications are that this number has not changed substantially.

TABLE I. Funding for basic research in Nuclear Physics by the federal (F) and state (S) governments in West Germany from 1976 until 1981. The numbers listed for the various major areas (medium energy, nuclear structure and heavy ions, and nuclear solid state physics) are taken from Ref. 1, and are in Million D of the respective years. Funds listed for 1976–78 are actual expenditures, those for 1979–81 are projections from the long-range plan.

	1976		1977		1978		1979		1980		1981	
	F	S	F	S	F	S	F	S	F	S	F	S
Medium Energy	32	16	30	17	31	18	34	19	35	20	37	21
Nuclear Structure and heavy ions	106	75	104	79	112	82	118	86	131	91	147	98
Nuclear solid state[a]	58	34	57	36	60	38	61	40	67	43	70	45
Total	196	125	191	132	203	138	213	145	233	154	254	164
Sum	321		323		341		358		387		418	
Annual increase			.6%		5.6%		5%		8.1%		8%	

[1] Programm Grundlagenkernforschung 1977-81, Bundesministerium fuer Forschung und Technologie, Bonn, 1978.

[a] Nuclear solid state is not included in the total numbers quoted in Table V.

The distribution of federal funds among the major institutes is given for 1978 in Table II.

TABLE II. Distribution of Federal Funding for Basic Research in Nuclear Physics in West Germany in 1978.

	MDm
Medium Energy Research	
Contribution to CERN	22
Contributon to SIN	5
Nuclear Research Center—Karlsruhe	1
Research Support	3
Total	31
Nuclear Structure and Heavy Ion Research	
DESY - Hambury	1
GSI - Darmstadt	46
Hahn-Meitner Inst. - Berlin	15
Nucl. Res. Ctr. - Karlsruhe	5
Nucl. Res. Facility - Julich	16
ILL - Grenoble	4
Max Planck Inst.-Heidelberg	12
Research Support	13
Total	112

Recent Funding for Nuclear Research in Switzerland

Some systematic information on basic research in Nuclear Science in Switzerland may be obtained from a 1977 study by the Science Policy Commission of the Swiss Physical Society.* Funding for basic research in Switzerland comes from the federal government, and the Cantons (or states), with a typical distribution of 90% and 10%, respectively, between the two sources. The largest share of the money goes to the Swiss Institute for Nuclear Research (SIN) which concentrates on medium-energy physics, but also does some low-energy nuclear research. The remaining funds go for low energy nuclear structure physics at universities and the Swiss Institute for Reactor Research (EIR). The latest numbers supporting these various aspects have been obtained for the year 1978 from the Swiss Office for Science and Research. The numbers listed in Table III include federal and state funds expenditures. The 1977 study lists a total of 140 scientists engaged in nuclear physics research in 1975. Inflation in Switzerland has been about 1% per year. A comparison of West German and Swiss expenditures on basic research in nuclear physics indicates a very similar level of support in both countries, per active scientist.

TABLE III. Estimated Support of Nuclear Physics in Switzerland in 1978 from federal and cantonal (state) sources.

Medium energy	28.3 M SF
Low energy at SIN	9.4 "
Nucl. Structure at Universities	10.1 "
Total	47.8 M SF

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*Physikalische Forschung in der Schweiz, Schweizerische Physikalische Gesellschaft, Bern (1977).

Funding for Nuclear Research in the United States

This information comes from the document "A Long Range Plan for Nuclear Science—December 1979" by the DOE/NSF Nuclear Science Advisory Committee, H. Feshbach, Chairman.

The approximate totals, including construction, accelerator improvements and equipment funds, for DOE and NSF are M$126, 129, and 141 for 1978, '79 and '80, respectively. We adopt the average of M$132 and add M$6 as a rather optimistic estimate for all other sources (state, industrial, other federal) for a total of M$138. The number of Ph.D. nuclear scientists, active in basic research in the U.S. was given by Fay Ajzenberg-Selove as ~1350. This was based on the "1978 Census of Basic Nuclear Scientists in the U.S.A." by F. Ajzenberg-Selove et al.

Comparisons in Funding

Such comparisons are always difficult. Is there an absolute level a national effort in research has to reach for it to be viable? Or should the effort be proportional to GNP or to population? Can the U.S., with more than three times the gross national product of Germany get along with supporting basic research at about the same absolute level? We cannot answer such complex socioeconomic questions substantively here.

There are technical questions on how to convert currencies in countries with differing inflation rates and exchange rates that are fluctuating by ±10%. This problem we solve by adopting 1.85 Deutsch Marks and 1.75 Swiss Francs as the equivalent of $1.00 US, an approximate average for the period in question. But we have obtained values of the GNP in the appropriate national currencies as well, and the conversion factors do not enter the ratios. The information is summarized in Table IV.

Table IV. Financial Comparisons

	Basic Research Nuclear Physics Budget	Gross National Product	Research Investment per Billion of GNP (BRNP/GNP) x 10^9 Present	1975[g]
Germany	259 MDm = M$140[a]	1394[d] BDm = B$753	190,000	260,000
Switzerland	47.8MSf[b] = M$27.3	157.4[e] BSf = B$89.9	300,000	240,000
U.S.	M$138[c]	B$2369[f]	58,000	67,000 (125,000 for 1967)

[a] Average of 1978,'79 and '80 from Table I; conversion factor 1.85.

[b] 1978 Budget Table III; conversion factor 1.75.

[c] Average of 1978, '79, and '80; see text.

[d] This is the 1979 estimate, 8.3% above the 1978 value (German consulate, Chicago). It is adopted in lieu of the 1978, '79, '80 average.

[e] 1978 estimate (Swiss consulate, Chicago).

[f] This is the 1979 estimate, 11.3% above the 1978 value. It is used in lieu of the 1978, '79, '80 average.

[g] From Appendix A.

It is clear from these results that the relative funding of basic research has not changed much since the time the Friedlander Report was prepared four years ago. (Appendix A). *About four times as big a fraction of the gross national product is spent on basic research in nuclear physics by most advanced western countries as is spent in the United States.* This ratio is not unique to nuclear physics—the factor in high-energy physics is about 2.5.

Demographic Comparisons

These data probably entail larger uncertainties than the fiscal information. As far as one can judge, the criteria were similar, all people who considered themselves active in basic research in nuclear science were counted with no attempt to correct fractional times spent in teaching and other activities. The results are summarized in Table V.

TABLE V. Demographic Comparisons

	Number of B.R.N. Physicists[a]	Population (millions)	Ratio (Physicist/ million pop.)	Research Budget[a] / Physicist (K$)
Germany	818	61	13	171
Switzerland	140	6.3	22	195
U.S.	1350	220	6	102

[a] Uncertainties in these numbers are estimated as ±25%.

From these comparisons it becomes evident that the imbalance in funding has had the consequence of reducing the number of active research physicists. Thus, while the research investment, per GNP is factors of three to five higher, the US scientific community has been reduced substantially to absorb some of this difference, the money per active physicist is only a factor of ~1.8 less here than abroad. It is also evident from the data in these tables that the differences in the per capita GNP are ~30% and cannot be held as the reason for the large differences ~~in~~ research investment.

Research Comparisons

Here it becomes difficult to make quantitative comparisons. If one views roughly comparable labs – e.g. the SIN (Zurich) meson facility vs LAMPF (Los Alamos) the UNILAC (Darmstadt) heavy ion accelerator vs SuperHILAC (Berkeley), the MPI (Heidelberg) tandem laboratory vs the Brookhaven tandems, the Munich Universities' tandem vs the largest US university tandem labs, one is inevitably struck by the fact that the European facilities are designed and built with a much larger factor allowed for assured operation, the laboratories are much better equipped, have larger scientific staffs and considerably larger technical support staffs. The qualitative difference is evident, even to the casual visitor.

The effects of the difference are also becoming evident. While the US community retains considerable momentum based on experience gained in the 1960's, the work of European labs increasingly dominates the Letters Journals where "new and important results" are published. This is demonstrated in a sample from Phys. Rev. Letters shown in Table VI . Phys. Rev. Letters has an especially strict refereeing standard and thus perhaps provides some measure, however flawed of research quality. Since it is a U.S. journal, the absolute percentage of papers may still not be a true measure of "important" contributions, since the non-U.S. authors often have their own journals, (or Physics Letters) and may have inhibiting language barriers. Also, refereeing criteria have changed somewhat, so absolute numbers over two decades are not very meaningful. But the variation in the ratio does tend to remove such problems and is the best index we could find of national shifts in forefront research.

TABLE VI . U.S. and Non-U.S. Origin of Phys. Rev. Letters Published in the Field of Nuclear Physics

Year	U.S.	Non-U.S.	Ratio (Non-U.S./U.S.)
1959 (July-Dec.)	38	11	0.29
1969 (July-Dec.)	41	14	0.34
1979 (July-Dec.)	56	36	0.64

International Cooperation in Nuclear Physics

Ever since World War II U.S. laboratories have benefited enormously from a steady flow of foreign visitors, mainly from Europe and Japan. Many of them were supported entirely or in part by their own funds, often supplemented by a NATO fellowship. In a few cases, formal agreements have been made between US and foreign laboratories for exchange of scientific staff, but in general the flow in both directions has been arranged through personal contacts and the mutual interest of the visitor and the host laboratory.

While such an informal system has obvious benefits of simplicity and flexibility, it necessarily limits the scale of inter-laboratory collaborations. If present trends continue, it may well come about that future accelerators for nuclear physics will exceed in cost what individual nations are willing or able to support. Moreover, the user community within any one nation might conceivably be too small to justify the construction of an expensive accelerator. If this situation should ever arise, it would be logical to consider some form of cooperation between two or more nations, and necessarily this would require the negotiation of formal agreements between governments. To prepare for this eventuality, it seems wise to make a start on a small scale so that not only scientists but also funding agencies and gove.nment departments can learn how to work together. There are encouraging signs that events are moving in this direction, and that formal inter-government agreements will soon be made between the US and Japan and between the US and the Peoples Republic of China.

U.S.--Japan Collaboration

Under the agreement between President Carter and Prime Minister Fukuda, Japan contracted to support very substantial amounts of energy-related R&D, most of the funds to be spent in the U.S. From the start, Particle Physics was included in the general agreement. Specific exchange arrangements have been worked out for whose support the Japanese Government is expected to appropriate $6M for the Fiscal Year beginning April 1st 1980.

At its November 1978 meeting at Stanford, NUSAC expressed strong support for the inclusion of nuclear physics and asked Willie Fowler and Bernard Harvey to see what could be done. Willie obtained permission from Presidential Science Advisor Frank Press for negotiations at the scientific level, leading to the possibility of including nuclear physics at a later date.

In March 1980, Bernard Harvey visited Japan for two weeks at the invitation of the Science and Technology Agency (STA), the funding agency for the Institute of Physical and Chemical Research (IPCR) (Tokyo) and the Japan Atomic Energy Research Institute (JAERI) whose 20 MV tandem accelerator is nearing completion. There is tacit agreement between STA and DOE that cooperative arrangements between U.S. labs, IPCR and JAERI should be worked out at the scientists' level for possible ratification at the government level at a meeting in early June.

In order to make definite plans on a rather short time scale, DOE would like to see draft agreements between pairs of labs drawn from the following list: ANL, ORNL, Texas A&M and LBL in the U.S. and IPCR and JAERI in Japan. All labs involved on both sides are aware of the interests of their potential partners.

The Japanese University labs (including the National Laboratory Research Center for Nuclear Physics at OSAKA) are funded by the Ministry of Education (MOE). This ministry already has an agreement with LBL for the support of a Japanese research group at Bevalac. While MOE may be willing to expand this existing agreement, there seems to be little support for entering into any new ones.

While the nature of the future DOE-STA agreements remains to be determined in detail, some broad outlines are already clear. The Japanese labs are most interested in exchanges in heavy ion physics, accelerator technology and instrumentation. They would like to see U.S. physicists working at IPCR and JAERI when these facilities are in full operation. Japanese physicists want to expand their research in U.S. labs, especially in those that offer special facilities or expertise. The overlap between the U.S. and Japanese interests seems to be sufficiently strong that, hopefully, the first few model agreements can be worked out in the next few months.

U.S-Peoples Republic of China Collaboration

A U. S. nuclear physics delegation visited the PRC in May and June 1979. A Chinese delegation will tour the U.S. in May 1980: discussions of collaborative research activities will be held and there seems to be no doubt that some form of agreement will be worked out. Very probably a U.S. delegation will visit the PRC later in 1980 to finalize the arrangements.

4.3 FUNDING OF NUCLEAR SCIENCE IN OTHER COUNTRIES

The Panel collected some data on the funding of basic nuclear research in a number of technically advanced countries. This information came partly from government agencies and partly from scientists familiar with overall funding in their countries. The request was for

> The total annual level of expenditure in basic nuclear research. This should include everything: salaries (scientific, technical, and service), operating costs, equipment, construction of buildings and facilities, in low- and medium-energy, and heavy-ion nuclear physics.

The results of this survey are given in Table 4.1, together with comparable figures for the Gross National Products (GNP) of the same countries.

Two features are clear from this comparison. One is that in absolute terms the U.S. investment in basic nuclear research is comparable with that of France and Germany. The other is that the fraction of GNP invested by the United States in this way is a factor of 3 to 4 smaller than that of the leading European countries (Germany, France, Switzerland) and substantially smaller than in Holland, Denmark, Canada, or indeed the United States of a decade ago. Of all the technologically advanced countries included, only *Japan* and Italy have a lower fraction invested in nuclear research in 1975 than does the United States.

It should be emphasized that the numbers in Table 4.1 are *no more than a rough indication* of research funding. For countries with a small GNP, the ratio of nuclear research budget to GNP is probably less meaningful than for others, because the cost of a viable program is relatively fixed. Budgets are categorized differently in each country, but an attempt was made to include university, state, and industrial contributions to basic research, to exclude classroom teaching, but to include the cost of the research part of graduate education. In many cases, the dividing line is somewhat arbitrary. Overall the margin of error is perhaps 20 percent.

TABLE 4.1 International Funding for Basic Nuclear Research

Country	Basic Nuclear Research Budget (NRB) (Millions/yr)[a]	 Source[b]	Gross National Product (GNP)[c] (1975 Billions/yr)	NRB/GNP
Germany	110	Heidelberg [illegible] Munich [illegible]	419	2.6×10^{-4}
U.S. (FY 75)	106	Div. Nucl. Phys. [illegible]	1516	0.7
U.S. (FY 65)	99	Nat. Acad. Sci. ([illegible] Report)	[illegible][h]	[illegible]
France	70[d]	Ministry of Industry and Research	338	2.1
United Kingdom	17[e]	Sci. Res. Council	214	0.8
Switzerland	14	Zurich [illegible]	59	2.4
Canada	15[e]	Nat. Res. Council of Canada	165	0.9
Italy	11[f]	Bologna [illegible]	171	0.6
Netherlands	8.2[g]	FOM (Netherlands [illegible])	79	1.0
Japan	9	Tokyo	482	0.2
Denmark	3.7	Copenhagen [illegible]	36	1.0

[a] Values for 1975 unless otherwise noted, converted to U.S. dollars at 1975 rates unless otherwise noted (Statistical Abstract of the United States 1976, Table [illegible]).
[b] [illegible] official [illegible] of university institute or laboratory or the responsible official of funding agency.
[c] Values of GNP for 1975 with the national currencies converted to U.S. dollars (Statistical Abstract of the United States 1976, Table [illegible]) except where noted.
[d] Includes $2 million estimate for university salaries.
[e] [illegible] average of nuclear research funding 1970-1975. GNP is for the same period from same source as given in footnote c.
[f] [illegible]
[g] [illegible] nuclear budget, [illegible] footnote c.
[h] GNP for 1965.

State of California
WASHINGTON OFFICE
600 PENNSYLVANIA AVE. S.E. [illegible]
WASHINGTON D.C. [illegible]
(202) [illegible]

EDMUND G. BROWN JR.
GOVERNOR

TESTIMONY OF

ELINOR SCHWARTZ
ASSISTANT DIRECTOR FOR ENERGY

BEFORE THE

ENERGY RESEARCH AND DEVELOPMENT SUBCOMMITTEE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

My name is Elinor Schwartz. I have represented the California Governor's Office and the California Energy Commission in Washington for more than five years. California has sought to diversify as well as conserve its energy sources. For example, the use of solar energy has expanded with direct financial incentives such as the 55 percent solar tax credit and utility solar financing demonstration. The Energy Commission has promoted passive solar designs through its building standards and has provided technical assistance to local governments preparing their own solar ordinances and establishing their municipal solar utilities. The Commission has funded direct heat geothermal projects as well as demonstrations of agricultural waste products for process heat. The Commission has also performed resource assessments and evaluated hydroelectric, wind, and cogeneration technologies as well.

The State has pledged its resources to further the creation of energy options that reduce vulnerability. It cannot do this job alone. It looks to the federal government to continue its traditional role in research and development, one that has been far more balanced than the technological favoritism shown in the President's proposed budget this year.

This statement will focus only on five areas under the subcommittee's jurisdiction, urging continued federal support for (1) the Heber Binary Geothermal Project; (2) the Salton Sea Solar Pond Powerplant; (3) the SMUD Photovoltaic Project; (4) the Geothermal Loan Guarantee Program; and (5) the Barstow Solar Central Receiver. Additional material on the Salton Sea project has been attached.

HEBER BINARY GEOTHERMAL PROJECT

Completion of the Heber binary geothermal project has been a major California R&D objective throughout the many years of consistent Congressional support. There is good reason. This 50 megawatt (65 Mw gross input) plant will be the first commercial scale binary facility using liquid dominated resources. It is expected to open the way to development of moderate temperature resources, which account for 80 percent of the hydrothermal reservoirs. In California alone, according to Geological Survey Circular 790, there are enough geothermal resources in the 150° to 210° C temperature range to produce over 3500 megawatts of electricity.

The consequences of terminating federal funding for the project, as suggested in the President's budget, would be (1) the loss of previously committed federal funds ($19 million, which would be paid back during commercial phase); (2) the loss of previously committed private funds, the source of more than half of the project costs; and (3) the lack of commercial scale operating experience for utility decision makers, which could result in the delayed use of moderate temperature geothermal resources or continued use of a technology without the environmental and cost advantages of a closed heat exchange system that returns brine to its reservoir. The importance of this project has even increased with the abandonment of the New Mexico flash demonstration late last year.

The California Department of Water Resources is taking an equity position in the project, which is budgeted for $2 million. The consortium, headed by San Diego Gas and Electric Company, includes the Electric Power Research Institute, the Imperial Irrigation District, the California Department of Water Resources, and Southern California Edison. Construction is expected to start this year. The purchase of major pieces of equipment, including the turbine, have been delayed for weeks or months pending DOE approval. Major equipment together with detailed engineering expenditures would amount to $23 million in FY 83. The consortium and other developers of hydrothermal resources are beyond the philosophical arguments about commercialization. They look to this Committee for its continuing leadership and support for binary technology.

SALTON SEA SOLAR POND

Recognizing that this is not a propitious time to raise a new project with the Committee, it is still important to note when ongoing research of wide applicability has reached the stage appropriate for starting a pilot plant. This is the case of the Salton Sea Solar Pond 5 megawatt project in Southern California. The purpose of this project would be to obtain hands-on experience in the design, construction, and operation of a solar salt pond generating facility that would serve as the foundation for design and construction of a 600 megawatt commercial generating facility at the Salton Sea. It would also establish a technical basis for the application of this technology as an energy source for applications in other parts of the country.

The unique energy storage feature of the solar pond enables it to produce power both day and night during any season of the year. Stratified layers are created that trap solar heat in the highly salty bottom layer, while the next higher layer acts as an insulator. Convection is reduced by floating nets on the top layer. Hot brine (about 200°F) is piped from the bottom through heat exchangers to vaporize a working fluid, which drives a turbine generator combination. The vapor is then condensed by cool water piped from the upper layers of the pond. All three fluids are recycled. The salt concentrations are maintained by adding concentrated brine at the bottom and by washing the surface with less saline water from the adjacent main pond.

The Department of Energy (DOE) has been an active partner in the preliminary studies that have resulted in highly positive technological feasibility and environmental assessments. DOE is now funding 50% of the preliminary engineering and cost optimization study, the California Energy Commission and Southern California Edison are each funding 25% of the $1.3 million study. Joint funding of the pilot plant is proposed on the same basis, with the Jet Propulsion Laboratory serving as General Project Manager.

Aside from minor funding for preconstruction water clarity and soils work possible under the Administration's proposed budget, another $2 million is needed as the federal share of the project in order for construction to begin on schedule in FY 83. A total of $23 million of federal funding (as spent) would be allocated over four years. About five years of testing at the free Naval Parachute Test Range site would provide the information necessary to scale up the project to commercial size at the next order of magnitude.

Although solar pond technology has been studied for over 20 years, it has only recently become feasible to apply it to large scale energy production. The first experimental ponds were developed in Israel, at the Dead Sea. Ormat's research pond completed there in December 1979 has produced 150 kilowatts of electricity. Ormat is now developing its own 5 megawatt facility. Much can be learned from this ongoing experience. However, the Dead Sea brine concentration is almost another order of magnitude, 280,000 ppm versus 37,000 ppm at the Salton Sea. A different set of issues is involved at the Salton Sea in determining methods of accelerating brine concentrations, while maintaining the brine in solution. Hydraulic and thermodynamic behavior management of thermally stratified ponds is the key to commercial development. Methods for maintaining water clarity and suppressing waves also need to be improved along with instrumentation and controls.

A commercial scale facility at the Salton Sea with a thirty year life could be privately constructed at the cost of about $1800 per kilowatt of installed capacity (1980 dollars), which is comparable to coal-fired or nuclear generating systems. Pond technology isattractive not only for its low operating cost, but also for its environmentally benign nature. In fact, a side effect of this facility would be a reduction in Salton Sea salinity, which is threatening the existence ofmany of the species inhabiting it, because of 4 million metric tons of salt received each year.

Clusters of 20 to 50 megawatt commercialscale modules could provide 600 megawatts at the Salton Sea alone. In the year 2000, potentially 580 million barrels of oil could be displaced per year from electrical production by solar ponds in the Southwest, Salt Lake, Gulf Coast, and Red River areas. A minimum of 920 million barrels of oil per year could be displaced in direct heating uses by solar ponds in those areas plus in the Black Hills, Pacific Northwest, Atlantic Northeast, Great Lakes, and Tennessee Valley. With the exception of Alaska, solar ponds could provide thermal energy at sufficiently high temperatures for space and water heating of building clusters in all regions of the U.S. Solar ponds could also lend their thermal, mechanical, or electrical energy applications to desalinization and a variety of agricultural uses, such as irrigation pumping, crop drying and space conditioning.

SMUD PHOTOVOLTAIC PROJECT

The Commission also urges federal support for the second megawatt of the 100 megawatt Sacramento Municipal Utility District Photovoltaic Project. The $7 million requested will enable the next set of bids to take place in FY 83. This front-end support will enable the project to get underway while the cost of photovoltaics exceeds that of alternate generation technology. The federal government is to be repaid for taking this risk later in the project's development. The State Energy Commission budget contains a $2 million contribution to the first megawatt, helping to match the $6.8 million in federal funds for FY 82. This project will be the largest central station photovoltaic project and will provide a major boost to the industry. The project will also provide an opportunity to perfect fabrication and construction techniques as well as to optimize efficiency and safety under high voltage conditions.

GEOTHERMAL LOAN GUARANTEE

The California Energy Commission has been encouraged by this Committee's continued support for the Geothermal Loan Guarantee. The Commission would oppose the Administration's arbitrary termination of new commitments at the end of FY 82, if any of the presently available guarantee authority had not been obligated. It is too early in the development of this industry to foreclose opportunities to small independent companies that are initially dependent on venture capital for both capital and operating costs. Although they may have considerable technical expertise, they may not be in a position to pledge the assets that a major corporation could. Because of their cash flow positions, they are not in a position to sit on leases, waiting for alternate fuel price increases to bid up the value of their resources.

It would be appropriate to leave open the option for any of the $364 million in currently uncommitted funds that remain in FY 83 to be used for follow-on support for powerplants at developed fields or for projects that might not have been ripe before the application deadline. The Energy Commission's contributions to geothermal resource development have included the streamlining of powerplant certification, resource assessments, and environmental studies.

BARSTOW SOLAR THERMAL CENTRAL RECEIVER

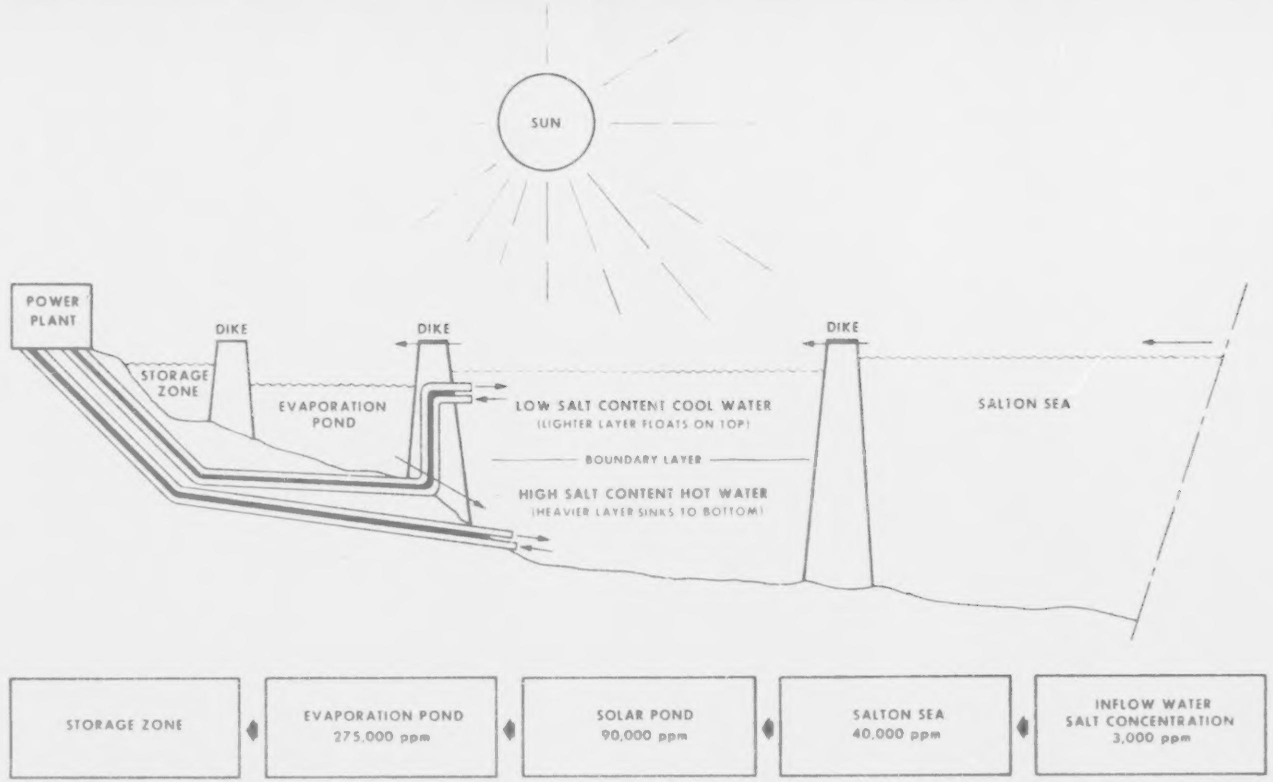
The 10 megawatt Barstow Solar Thermal Electric project is nearing completion. The system is scheduled to begin operating in Barstow, California by this summer, following a set of tests mandated by the Department of Energy. These tests will include calibrating the movement of sun-tracking mirrors (heliostats) that concentrate solar radiation to heat steam that, in turn, drives a turbine to produce electricity.

This pilot is the largest solar thermal project in the U.S. In addition to gaining essential operation and field experience, this project will help determine the costs of solar thermal electricity at various rated capacities in order to maximize cost effectiveness. This information will be directly useful to the 100 megawatt solar thermal project being considered by the lead member of the consortium, Southern California Edison, as well as to additional hundreds of megawatts in longer term plants of other utilities. The State Energy Commission has contributed $50,000 to the environmental impact report for the project.

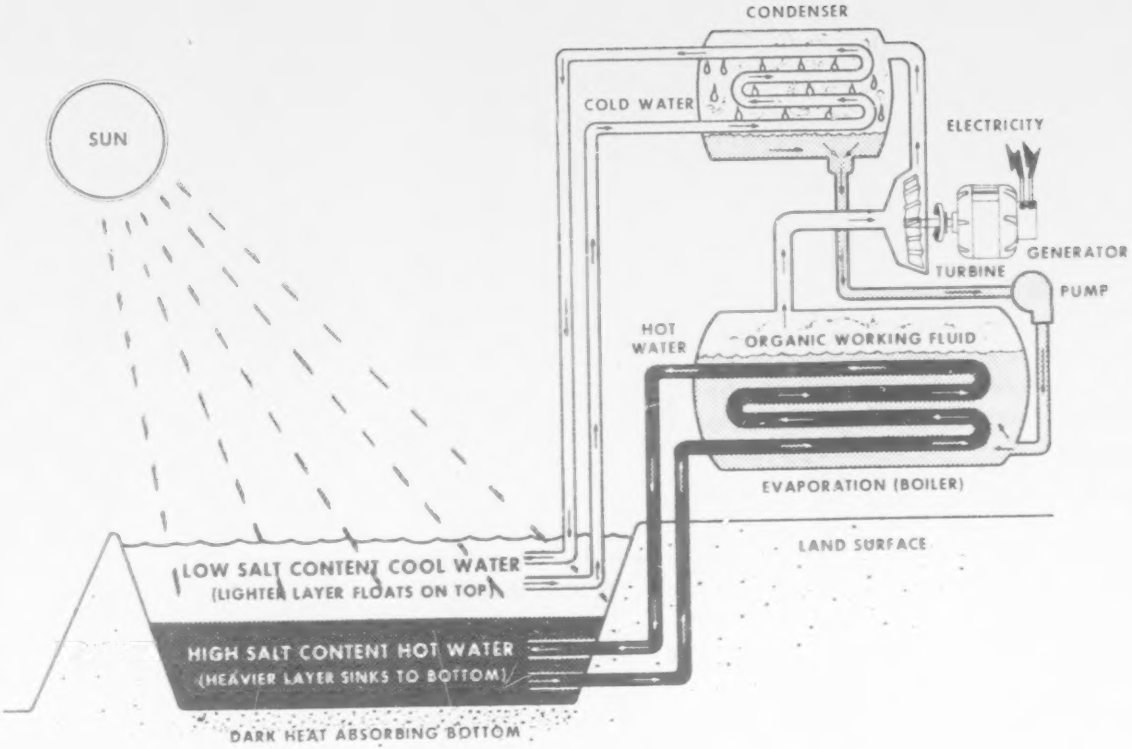
Table I

DESIGN CHARACTERISTICS OF 5MW SOLAR SALT POND POWER PLANT

Gross Power Output	5000 KW
Net Power Output	4000 KW
Load Factor	.7 (5800 hr/year)
Power Module Heat Input	178 MBtu/hr
Power Conversion System Efficiency	9.6%
Overall Plant Thermal Efficiency	2.2%
Hot Brine Flow Rate	44,000 gpm
Hot Brine Temperature	185°F
Hot Brine Specific Gravity	1.22
Cooling Water Source	Salton Sea
Cooling Water Flow Rate	44,000 gpm
Cooling Water Temperature	73°F
Organic Working Fluid Flow Rate	800 lb/sec
Turbine Inlet Pressure	133 psi
Turbine Outlet Pressure	37 psi
Solar Pond Area	60 Acres
Pond Depth	16.5 feet
o Thermal Storage Zone	11.5 feet
o Nonconvective Zone (Insulation Layer)	4.25 feet
o Upper Mix Layer (Convective Layer)	.75 feet


SUN
POWER PLANT
DIKE
DIKE
DIKE
STORAGE ZONE
EVAPORATION POND
LOW SALT CONTENT COOL WATER
(LIGHTER LAYER FLOATS ON TOP)
BOUNDARY LAYER
HIGH SALT CONTENT HOT WATER
(HEAVIER LAYER SINKS TO BOTTOM)
SALTON SEA
STORAGE ZONE
EVAPORATION POND 275,000 ppm
SOLAR POND 90,000 ppm
SALTON SEA 40,000 ppm
INFLOW WATER SALT CONCENTRATION 3,000 ppm

Salton Sea commercial solar pond concept


CONDENSER
COLD WATER
ELECTRICITY
SUN
GENERATOR
TURBINE
PUMP
HOT WATER
ORGANIC WORKING FLUID
EVAPORATION (BOILER)
LAND SURFACE
LOW SALT CONTENT COOL WATER
(LIGHTER LAYER FLOATS ON TOP)
HIGH SALT CONTENT HOT WATER
(HEAVIER LAYER SINKS TO BOTTOM)
DARK HEAT ABSORBING BOTTOM

Solar pond generating concept

STATEMENT ON THE FY 1983 FUEL CELL BUDGET
OF THE DEPARTMENT OF ENERGY

presented to
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
U.S. SENATE
by
THE FUEL CELL USERS GROUP OF THE ELECTRIC
UTILITY INDUSTRY, INC.
April 28, 1982

The Fuel Cell Users Group is broadly based, encompassing utilities of all sizes and types, and with representatives of all segments of the electric utility industry. The more than 55 utilities (investor-owned, public and cooperative) that make up the users group represent about 40% of the electric generating capacity in the United States. These utilities are all potential users of the fuel cell technology, and all see great future potential for the fuel cell to meet a variety of unique power plant and siting requirements. Together they are working with the Electric Power Research Institute (EPRI), the manufacturers and the Department of Energy to identify and solve issues which are obstacles to the commercialization of the fuel cell.

Our purpose in presenting this statement is threefold:

- To offer the full support of the Fuel Cell Users Group in a "partnership role" in joint efforts toward the rapid commercialization of the phosphoric acid fuel cell for power generation;

- To point out briefly some of the many and unique potential environmental, economic and efficiency advantages of the fuel cell technology when used in a power generation mode; and

- To urge Federal funding for continued technological research and development for the fuel cell commensurate with its potential for early, successful commercialization. We respectfully recommend and urge that FY '83 funding be continued at the FY 1982 level ($34.5 million) and that Federal priorities be established to provide a policy for consistent support for commercialization of the technology.

FUEL CELL ADVANTAGES

We are firmly convinced that the commercialization of the fuel cell is in the national interest because of its environmental, economic and efficiency attributes. Conceivably, it could revolutionize the energy industry the way solid-state components changed the electronic industry.

Generation efficiencies of from 41% to 50% can be expected from the fuel cell (in contrast to 28% to 38% for conventional thermal power plants) giving it fuel saving or conservation qualities so essential in today's energy climate. The fuel cell also operates efficiently at partial loads, which allows the utility to use this versatile system in a load-following mode as a substitute for intermediate or peaking equipment.

Efficiencies can be further enhanced by using the fuel cell in a cogeneration mode--by effectively utilizing waste heat. By fitting the fuel cell with equipment to recover the reject heat, the power plants can supply steam or hot water for process industries and building heating systems. Overall fuel conversion efficiencies (thermal plus electric) of 80% are possible utilizing fuel cells in this manner.

Environmental acceptability and modular construction are important advantages of the fuel cell, making it relatively easy to site. For example, emissions of oxides of nitrogen and sulfur and particulates will be at least a factor of ten below what is currently attainable from fossil fuel plants. Noise levels will be low (about 55 decibels at 100 feet). Water use will be negligible, and land requirements modest (less than one acre for a utility scale, 11 MW facility). The modular construction and prefabrication of major components is expected to permit the installation and startup operation of a fuel cell on a two-year time scale. This is particularly important to utilities in terms of planning flexibility and local siting, and also in delaying capital investment until additional capacity is required.

Fuel flexibility may also be an advantage. First generation fuel cells will be able to use petroleum or coal-derived distillates, natural gas, methane, coal gas, synthetic natural gas or fuel grade methanol. These fuels include methane-rich gases which might be produced from landfills, sewage, feedlot wastes, abandoned coal mines, and other unconventional sources. The fuel cell's capability for being installed in relatively small capacity increments and siting in a variety of environments could enable it to use methane derived from such sources as either a primary or supplemental fuel.

Rural electric cooperatives often have access to such fuel sources and could make effective use of relatively small increments of power generated from such sources. Also installations of unattended fuel cell plants at substation sites could forestall or eliminate the need for heavying up transmission lines, and improve reliability.

The Users Group in a Partnership Role

The electric utility industry has already made a major commitment to the development and commercialization of fuel cell power plants. In the decade from 1971 to 1981, EPRI, investor-owned electric utilities, fuel cell manufacturers and others invested over $150 million in the development of the phosphoric acid fuel cell, compared to Federal funds of approximately one-third that amount. This does not include substantial in-kind contributions by members of the Fuel Cell Users Group in their support of commercialization efforts.

The Users Group and individual utility members are prepared to continue to provide support in areas which will lead toward the goal of commercial introduction of the fuel cell as a viable utility power plant. We are prepared to work with the manufacturer to provide guidance in development of the final specifications for the fuel cell, to assist in identifying early users; to collect data, analyze costs and determine the availability of the technology; to identify gaps in research which are either not currently being funded or are inadequately funded; and to support early purchasers by providing them with evaluations of the proposed commercial configuration.

Our major concern is that present financial problems facing the utility industry will not allow us to proceed without continued financial assistance from the Federal government. The industry is not in a position to assume the financial risks associated with the high cost of technical research and the experimental fuel cell power plants needed to refine and prove the technology.

Without an ongoing technology development program, the utility industry will not be assured that a final acceptable commercial product will be developed. It is here that we propose that the Federal government could assume its proper role by continued financial support of important technology base programs aimed at upgrading fuel cell performance in critical areas, especially those which have been identified by the utilities themselves.

Consistency and stability in government support is essential for the succesful early commercialization of the fuel cell technology. Utilities are not likely to make the major commitments required for the purchase of the early units unless there is assurance of Federal government support and determination to see the project through to a succesful completion.

In addition, we should not overlook the interest shown by foreign countries in the fuel cell technology. Tokyo Electric is installing and will soon demonstrate a 4.8 MW power plant similar to the Con Ed plant, but with an advanced stack design. Unless we move expeditiously to commercialize the technology in this country, we could find ourselves purchasing fuel cell power plants from Japan where, historically, the government provides strong financial support for research and commercial development of new technology.

CONCLUSION

In summary, we members of the Fuel Cell Users Group find the fuel cell's promise to be extraordinary, but the proof of its attractive characteristics (fuel flexibility, reliability, efficiency, environmental acceptability, and economic viability) continue to elude us. We believe that a partnership role between industry and government to support a broadly based program to prove out the capabilities of this energy option within the next three to five years would be fully consistent with our national priorities of energy self-sufficiency, economic well-being, and environmental health. We, therefore, urge that Federal fuel cell funding be continued at the FY 1982 level ($34.5 million) for next year.

Thank you for the opportunity to present this statement on behalf of the Fuel Cell Users Group and NRECA.

ATTACHMENTS:

1. List of Fuel Cell Users Group members
2. January 15 letter to The President from William H. Corkran,Jr., Acting Chairman, Fuel Cell Users Group.
3. Resolution on "Federal Support for Fuel Cell Commercialization" confirmed by members of the National Rural Electric Cooperative Association at the annual meeting in Atlanta, February 10, 1982, attended by more than 9700 people

3/29/82

FUEL CELL USERS GROUP MEMBERS

- Adams Electric Cooperative
- Allegheny Electric Cooperative
- Alpena Power Company
- American Public Power Association
- Anchorage Municipal Light & Power
- Arizona Public Service Company
- Baltimore Gas & Electric Company
- Basin Electric Cooperative
- Boston Edison Company
- Brazos Electric Power Cooperative
- Buckeye Power, Inc.
- Central Hudson Gas & Electric Corp.
- Central Illinois Light Company
- Colorado Ute Electric Assoc., Inc.
- Commonwealth Edison Company
- Consolidated Edison Co. of NY
- The Dayton Power & Light Company
- Delmarva Power & Light Company
- Easton Utilities Commission
- Edison Electric Institute
- Electric Power Research Institute
- Green Mountain Power Corporation
- Hoosier Energy Division, REC, Inc.
- Hydro-Quebec
- Idaho Power Company
- Jacksonville Electric Authority
- Kansas City Power & Light Company
- Lee County Electric Cooperative
- Lincoln Electric System
- Long Island Lighting Company
- Massachusetts Municipal Wholesale Electric Company
- Memphis Light, Gas & Water
- Mississippi Power & Light Company
- Missouri Basin Municipal Power Agency
- National Rural Electric Cooperative Association
- Niagara Mohawk Power Corporation
- Northeast Utilities Service Company
- Ohio Edison Company
- Ontario Hydro
- Philadelphia Electric Company
- Provo City Power
- Public Service Company of Oklahoma
- Public Service Electric & Gas Company
- Rural Electrification Administration
- San Diego Gas & Electric Company
- Santa Clara Electric Department
- Seminole Electric Department
- Southern California Edison Company
- Southern Company Services, Inc.

Southern Maryland Electric Cooperative

Tacoma Department of Public Utilities

Tampa Electric Company

Taunton Municipal Lighting Plant

Tennessee Valley Authority

Tokyo Electric Company

Toledo Edison Company

United Power Association

Virginia Electric Power Company

Associate Members

Biltmore Development Company

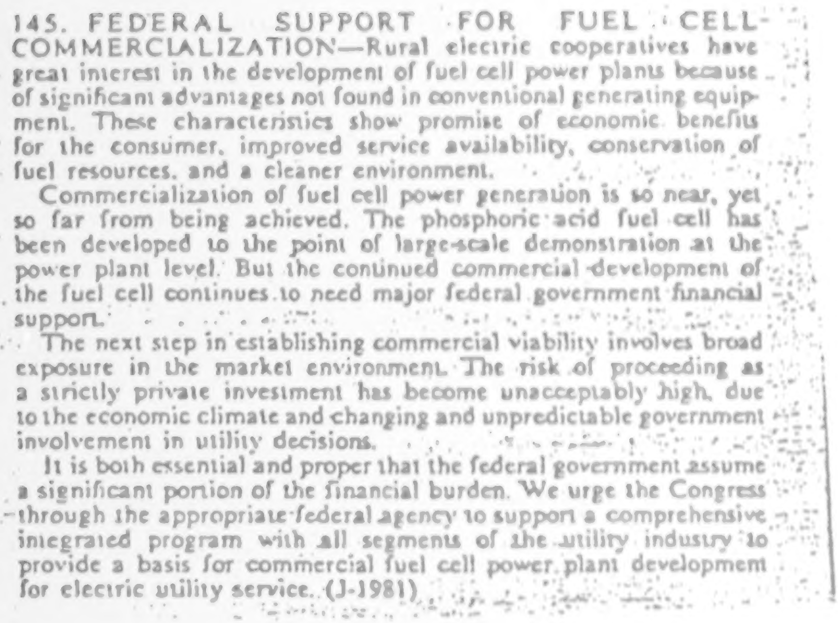
Burns & McDonnell Engineering Company

Burns & Roe, Inc.

Ebasco Business Consulting Services, Inc.

Johnson Matthey Research Centre

NUS Corporation



145. FEDERAL SUPPORT FOR FUEL CELL-COMMERCIALIZATION—Rural electric cooperatives have great interest in the development of fuel cell power plants because of significant advantages not found in conventional generating equipment. These characteristics show promise of economic benefits for the consumer, improved service availability, conservation of fuel resources, and a cleaner environment.

Commercialization of fuel cell power generation is so near, yet so far from being achieved. The phosphoric acid fuel cell has been developed to the point of large-scale demonstration at the power plant level. But the continued commercial development of the fuel cell continues to need major federal government financial support.

The next step in establishing commercial viability involves broad exposure in the market environment. The risk of proceeding as a strictly private investment has become unacceptably high, due to the economic climate and changing and unpredictable government involvement in utility decisions.

It is both essential and proper that the federal government assume a significant portion of the financial burden. We urge the Congress through the appropriate federal agency to support a comprehensive integrated program with all segments of the utility industry to provide a basis for commercial fuel cell power plant development for electric utility service. (J-1981)

Adopted by the membership of the National Rural Electric Cooperative Association at the annual meeting in Atlanta, February 10, 1982, attended by more than 9700 people.

THE FUEL CELL
USERS GROUP
THE ELECTRIC UTILITY INDUSTRY, Inc

[illegible] Connecticut Avenue, NW
Suite [illegible]
Washington, DC [illegible]
[illegible]

DIRECTORATE

Charles F. Luce
Chairman of the Board
Consolidated Edison
Chairman

William H. Carlson Jr
General Manager
[illegible] Commission
Vice Chairman

Richard C. Clark
Senior Vice President
Niagara Mohawk Power Corporation

Administrator
Rural Electrification Administration

[illegible]
Director of Electric Utilities
City of Santa Clara Electric Department

Richard M. Freeman
Director
Tennessee Valley Authority

William R. Gould
Chairman and Chief Executive Officer
Southern California Edison Company

[illegible]
President
[illegible] Power and Light Company

William F. [illegible]
Executive Vice President and General Manager
[illegible] Cooperative, Inc

William McCollam Jr
President
Edison Electric Institute

Robert D. Partridge
Executive Vice President and General Manager
National Rural Electric Cooperative Association

Alex Radin
Executive Director
American Public Power Association

[illegible] Ellis Jr
Chairman and Chief Executive Officer
Northeast Utilities Service Company

[illegible]
Chairman of the Board
Public Service Electric and Gas Company

[illegible]
Chairman and Chief Executive Officer
[illegible] General Electric Company

[illegible]
[illegible] Vice President
Consolidated Edison
[illegible] Committee

[illegible]
[illegible]
[illegible]
[illegible]

January 15, 1982

The President
The White House
Washington, D.C. 20500

Dear Mr. President:

I am writing to encourage continuation of adequate funding for research and development of fuel cell technology in the Department of Energy for FY 1983 and beyond. It has been reported that funding of $9.5 million for this technology is being considered for FY 1983, in contrast to appropriations of $34.5 million for FY 1982. This reduced funding level would undercut the efforts of the utility industry to commercialize fuel cell power plants.

The electric utility industry in the United States has made a major commitment to development and commercialization of fuel cell power plants. Between 1971 and 1981, the electric-utility sector (utility companies, fuel cell manufacturers and others) spent over $150 million on the phosphoric acid fuel cell program, as compared to federal funds of approximately one-third this amount. In 1980, the Fuel Cell Users Group of the Electric Utility Industry, Inc. was established to promote commercialization of fuel cell technology. The Users Group now has 64 public, private, and rural cooperative members representing some 40 percent of electric power sales in the United States. The Users Group, individual utilities, and the fuel cell manufacturers are in the process of developing an industry-supported program for fuel cell commercialization.

The industry commitment reflected in these actions is evidence of our conviction that the fuel cell offers important technical, financial, and environmental benefits to electric utilities. To realize these benefits, it is vital, as pointed out in your recent statement on nuclear policy, ". . . that the utilities - investor-owned, public, and coops - be able to develop new generating capacity to permit them to supply their customers at the lowest cost, be it coal, hydro, or new technologies such as the fuel cell." Moreover, the commitment of our industry to fuel cell commercialization is squarely in accord with your policy of relying on industry for the deployment of new energy technology, while limiting federal funding to higher risk research and development activities.

Although industry is prepared to take the lead in fuel cell commercialization, we can attain our goal only if industry and government work in partnership, each playing its proper role in an integrated and stable program. The need for such a partnership is particularly acute in developing new technologies in the electric utility industry. In a report to Congress of September 28, 1981, dealing with the ability of our industry to adopt new technologies, the General Accounting Office noted that ". . . the risk [of commercialization] is not just limited to development of new technology. Huge financial risk is associated with incorporating a newly developed and working technology into an established and complex electric power system so that it is both economical and reliable."

Because most electric rates are established by governmental authorities and because energy tax credits permitted other industries are not allowed to electric utilities, many of the usual incentives to take commercialization risks are not available to our industry. Thus, stability in federal research programs that help reduce technological risk is particularly important to our efforts. We are not able to make the large investments required for fuel cell commercialization unless we can rely on all participants in the program to play their appropriate role consistently.

Unfortunately, the federal role in the fuel cell program has not been consistent. Each year in the annual budget cycle, the content of the federal program has been completely reconsidered and funding levels have remained in flux until final appropriations action. This instability is in marked contrast to the aggressive Japanese fuel cell program, to which their government has made a long-term commitment. This program is subject to periodic substantive reviews, but not to annual reauthorization. It would be unfortunate if this serious and systematic Japanese effort to develop a fundamentally American technology were to succeed whereas ours failed because we were unable to forge the necessary partnership between public and private sectors.

The Fuel Cell Users Group is uniquely positioned to work with your Administration to develop a cooperative program for fuel cell commercialization within the context of your policies on federal energy and development. We plan in 1982 to work closely with the Department of Energy toward this end, and in the coming months will recommend specific program goals and implementing actions. However, this cooperation will not be possible at the reported funding level for FY 1983, which appears to represent withdrawal of the federal government as a partner in the total effort. As noted in the GAO report mentioned earlier ". . . Individual projects need to be carefully evaluated before they are discontinued. Cancellation of such R&D efforts on any other basis can result in commercialization of promising technology being delayed or lost."

We believe continuation of the federal program at the level of the fiscal '82 appropriations would be a more equitable federal share in view of the commitments being made by industry, and we therefore urge your reconsideration of fuel cell technology in the FY 1983 budget.

We look forward to working with your representatives in continuing an effective partnership to realize the cost, efficiency and environmental benefits of fuel cell power plants for our industry and for the nation.

Respectfully,

William H. Corkran J.

William H. Corkran, Jr.
Acting Chairman

STATEMENT
BY
JOHN T. CONWAY
PRESIDENT
AMERICAN NUCLEAR ENERGY COUNCIL
BEFORE THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

APRIL 26, 1982

My name is John T. Conway. I am President of the American Nuclear Energy Council -- a nuclear trade association located in Washington, D.C., with a membership of over 100 organizations including private, public and cooperatively owned utilities, manufacturers, architect-engineers, uranium mining companies and various other firms engaged in the nuclear fuel cycle. The Council supports energy conservation and the development of synthetic fuels, solar, fusion and other longer range energy resources, but holds that nuclear power is essential if this Nation is to have adequate and dependable electrical energy supplies throughout this century.

John T. Conway formerly was Executive Assistant to the Chairman of the Board, Con Edison, New York, for 10 years. For eight of those 10 years he was Chairman of the Nuclear Facility Safety Committee which had overall safety responsibility for Indian Point Units 1, 2 and 3. He has a BNS and BS in Engineering from Tufts College of Engineering and an LL.B. from Columbia University School of Law. From 1956 to 1968 he was on the staff of the Joint Committee on Atomic Energy, U.S. Congress.

Mr. Chairman and Members of the Committee, I am pleased to appear before you to discuss the FY83 nuclear fission energy budget. I should like to begin by attempting to put the FY83 nuclear budget into proper perspective.

FY83 Nuclear Budget

Some concern has been expressed that a disproportionate share of DoE's budget is being allocated to nuclear energy. In recent hearings, claims have been made that somewhere between 67% to 86% of DoE's budget is allocated to nuclear.

To the extent that these percentages are being cited to demonstrate that civilian nuclear energy is receiving an unfair share of Federal research and development funds, I believe them to be misleading because they include, under the heading of nuclear, certain projects that are related to the government's outer-space and military programs. For example, funds allocated to the Advanced Nuclear Systems ($31 million) directed toward the government's space efforts and Remedial Action to clean up military related mill tailings ($50 million) should not, in our opinion, be characterized as civilian nuclear energy programs. In addition, funding for fusion, a desirable program, should not be identified with the commercial nuclear energy program.

Recognition also should be given to the fact that $185 million earmarked for the nuclear waste fund is to be repaid directly by the industry.

Subtracting these elements from the nuclear total yields a more accurate sum for the civilian nuclear program of $750 million, which represents 34% of the $2.2 billion energy R&D budget. This sum represents a 25% reduction from the comparable FY82 total of $1.0 billion (again excluding Fusion, Advanced Nuclear Systems and Remedial Action).

Thus, nuclear energy has sustained a significant cut this year and is a much smaller percentage of the energy R&D funding than the critics maintain. It must also be remembered that for the period 1977 to 1981, the nuclear fission budget declined 15.4% in year of budget dollars, or by 42% in constant FY81 dollars. Finally, it should be pointed out that outside the R&D funding category, other energy sources enjoy government assistance in the form of tax credits, health benefits, depreciation allowances, and so forth.

Mr. Chairman, today nuclear energy is providing approximately 12% of our country's total electrical supply (see Attachment I). This year it is projected to become the second largest generator of electricity, surpassed only by coal. By 1990, as additional plants in the pipeline begin operation, its contribution will increase to between 22% and 25%. However, nuclear energy, along with coal, can and should contribute far more to our future energy security. The nuclear option is capable of providing hundreds of years of economic electrical power, independent of foreign energy sources.

Recognition of the critical role of nuclear power in this nation's energy future was made by President Reagan in his October 8 Nuclear

Policy Statement. In announcing a series of initiatives designed to restore vitality to the nuclear industry, the President stated: "One of the best potential sources of new electrical energy supplies in the coming decades is nuclear power." We applaud the initiatives proposed in the policy statement and are encouraged by the support provided nuclear programs in the FY83 budget.

We are heartened, in particular, by the President's recognition of the need to proceed with the Clinch River Breeder Reactor project (CRBRP). The Congress has repeatedly endorsed the principle that the CRBRP is a key step in the LMFBR program and that it must be expeditiously constructed to meet the objectives of the program. The previous Administration's actions delayed the project by more than five years and increased costs by more than $800 million. We can, however, pursue all possible efforts to minimize further delays in the project and costs to the taxpayer. As federal agencies involved in development and regulation of nuclear energy, DoE and NRC respectively, share a responsibility to assure that the Nation's energy future is fairly secured and that the taxpayers are well served.

Breeder reactors represent a tremendous source of energy. They can extend our uranium resources by a factor of about 60 times. The energy value of uranium already mined and above ground -- the by-product of our enrichment operations that can only be used in breeders -- is roughly equal to our total unmined coal resources or at least three times the total OPEC oil resources.

Clinch River is the right plant; it will operate at the right time; it can be built at the right cost, in the right place; and we believe the time to build it is right now.

We should also like to take this opportunity to express our support for completion of the full 8.8 million SWU capacity of the Gas Centrifuge Enrichment Project at Portsmouth, Ohio. We believe this highly energy efficient technology will ensure the continued reliability of nuclear fuel supply to both domestic and foreign reactors at a highly competitive price.

As you are aware, the enrichment program is operated on a full cost recovery basis and this fiscal year should return to the Federal Treasury $2 billion in revenues. Not only is the provision of enrichment services internationally of value from a balance of trade perspective, but also it ensures continued U.S. influence on foreign national nuclear programs and nonproliferation policy.

With respect to the Barnwell Spent Fuel Reprocessing Facility in South Carolina, we are pleased that the FY83 nuclear budget includes funding to continue the research and development program focused on using Barnwell for reprocessing, and the development and testing of advanced safeguards systems.

Additionally, we support the $27 million budget request for research and development related to the Three Mile Island Nuclear Power Plant clean up program. We believe speedy decontamination of this facility is essential to the public health and safety and continued confidence in the government's and industry's ability to conduct such activities.

Although funding was not included in the president's FY83 budget, Administration budget testimony has repeatedly addressed the desirability of pursuing High Temperature Gas Cooled Reactor Technology. The Congress has consistently supported this technology because of its potential to serve unique market areas that require high temperature operation. The high temperature system also offers several potential advantages, including increased energy efficiency, higher conversion efficiencies, the possibility of siting in areas now foreclosed to existing reactors and the potential for high temperature process steam and cogeneration. We support the Congress in its recognition of this technology and believe it should be funded again this year.

In the remainder of this statement we would like to focus on the nuclear waste program. This aspect of the FY83 nuclear budget must, we believe, receive priority attention this session of congress.

As you will note from the Public Opinion Poll shown in Attachment II, 95% of those polled consider the development of permanent sites for the storage of radioactive waste to be important. The poll also reveals that 92% agree that it is time the government moved ahead on a safe method of storing nuclear waste.

It is our view that there is enough information available to enable the Federal Government to proceed now on a conservative basis, to locate, design, construct and initiate the phased operation of a waste management system involving interim retrievable storage and final geologic disposal.

To this end, this Committee and the Committees on Environment and Public Works and Armed Services have reacted to the public's concern regarding nuclear waste disposal by reporting out waste proposals. I have sent to every member of the Congress, a letter signed by the top official of 76 electric utilities and associations, which serve over 160 million Americans, requesting Congress to pass a waste bill this year (see Attachment III). We would urge the members of the Energy and Natural Resources Committee to impress the public's concern upon your colleagues, and ask for speedy action in bringing a nuclear waste bill to the Senate floor.

In discussing any legislation concerning the implementation of a national waste management program, we believe, several important issues must be addressed:

- interim spent fuel storage;
- development schedule of geologic repositories;
- state participation; and
- financing spent fuel storage and high-level waste disposal programs.

We would now like to address these issues separately.

Interim Spent Fuel Storage

The Utility Nuclear Waste Management Group, the American Nuclear Energy Council, the Edison Electric Institute and the Atomic Industrial Forum have strongly supported the creation of away-from-reactor (AFR) spent fuel storage capacity by the Federal Government since the Carter Administration in April, 1977 "indefinitely" deferred reprocessing. Industry and the Department of Energy's own studies indicated that additional storage capacity will be necessary as early as 1986. In fact, based on data from a recent DoE survey of 67 commercial nuclear reactors, 62 were involved in expanding spent fuel storage capacity by reracking. Fifteen reactors were reracked for a second time and two reactors were undergoing a third reracking. Through 1990, there are limited options for the 26 plants which will require additional capacity. Taking into account economic, regulatory and technical considerations of the several possible options, the availability of AFRs appears to be the only assured option. AFRs would prevent the shutdown of a number of operating reactors prior to 1990 due to a shortage of storage space for spent fuel. The utilities' current spent fuel storage dilemma results directly from past government policy vacillations. Government assistance is needed to solve the problem with the clear understanding that all reasonable costs will be borne by the users of waste storage facilities. In addition, the Monitored Retrievable Storage (MRS) concept would provide several important advantages in managing and disposing of spent fuel and high-level waste.

Geologic Repositories

A considerable amount of research and development work has been accomplished during the past 20 years, in solving the waste management problem. Much of the technology required to dispose of nuclear wastes has already been developed. There are no insurmountable technical problems preventing the safe disposal of nuclear wastes in a geologic repository. In fact, only political problems are preventing the timely implementation of such a program.

It is our view that the development schedule for a repository should be firm and should provide for an operating repository within a reasonable time frame.

The Administration's proposed integrated test and evaluation facility would provide early technical data on repository designs and site specific information, and would serve to demonstrate to the public that the technology exists to dispose of nuclear wastes in a safe manner. It should not be a separate program, but rather an integrated program with the site characterization activities as are permitted by the NRC's rules for licensing a geologic high-level waste repository.

To ensure that the development of the repository proceeds smoothly, it also appears that any legislation on nuclear waste management should make clear what constitutes and what does not constitute a major federal action for NEPA purposes. It is our view that the final site selection by DoE for a permanent repository should be considered the only major federal action requiring the preparation of an EIS. NRC should be required to accept DoE's EIS so as to avoid unnecessary regulatory duplication. Furthermore, streamlining of the NRC review and hearing processes for the construction and operation of a repository is also required.

State Veto Rights

There appears to be a growing consensus that institutional issues pose the greatest risk of delaying implementation of a waste management program. These issues will require Congressional action to resolve the barriers which impede this progress. Foremost among the institutional issues is the question of the proper state role in the siting of a federal repository.

States have a legitimate interest in the siting of nuclear waste facilities which must be accommodated, but must ultimately be balanced against the overriding national interest. In the previous Congress, both the Senate and the House adopted a workable procedure for states to participate in the siting of federal nuclear waste facilities, including the right to object and appeal the site designation decision to both the President and Congress. We believe this compromise procedure adopted by both Houses should be maintained in the legislative proposals now under consideration.

Financing Spent Fuel Storage and High-Level Waste Disposal

The utility industry has always agreed to be responsible for the payment of the full cost of commercial waste management facilities. Several House bills call for payments to be made on the basis of user fees associated with spent fuel storage and disposal. The Senate bill (S. 1662) contemplates another approach whereby, for permanent disposal facilities, a mandatory fee in the amount of one mil per kilowatt hour of nuclear generated electricity would be collected from utilities operating nuclear plants. If this one mil per kilowatt hour fee had been levied during 1981, the total amount collected would have been more than $250 million. By 1990, the sum of all annual fees collected would total $4 billion to $6 billion, a significant sum to finance permanent waste disposal. The development of a Nuclear Waste Trust Fund for the administration of the program would be acceptable to the utility industry due to its belief that adequate financial resources must be available in order that the waste management program can be implemented in a timely manner. Such a program would be paid for by those benefiting from the electricity provided. Indeed, the FY83 nuclear waste budget assumes creation of a $185 million Nuclear Waste Disposal Fund It is, therefore, imperative that nuclear waste legislation be enacted early this session to prevent disruption of on-going nuclear waste programs previously funded under the DoE Budget.

If such financing proposals are to be considered, we believe the enacting legislation should authorize and direct the Secretary of Energy to enter into contracts with all nuclear power plant operators by which the government agrees by a date certain to take title to spent fuel at the reactor site.

An additional aspect of the cost of waste disposal facilities which we believe should be treated in legislation is appropriate financial assistance to state and local governments of areas affected by waste disposal facilities. This assistance should be provided to offset any direct or indirect costs incurred because of environmental, economic or other impacts resulting from such facilities. The cost of such financial assistance should be financed from fees collected from the utilities and paid into the Nuclear Waste Trust Fund.

Mr. Chairman, this concludes my statement. I thank you for the opportunity to testify before your Committee on the FY83 nuclear budget issues.

ATTACHMENT I

Atomic Industrial Forum, Inc.
Public Affairs and
Information Program

NUCLEAR POWER FACTS AND FIGURES

Decer

STATUS OF U.S. NUCLEAR POWER PLANTS AS OF DECEMBER 31, 1981

78 reactors with operating licenses[1]	59,321 M
74 reactors with construction permits[3]	82,308 M
2 reactors with limited work authorizations[4]	2,300 M
12 reactors on order	13,996 M
166 total commitments	157,925 to

[1] Includes 72 reactors (55,092 Mwe) licensed for commercial operation, 1 reactor full-power operating license (Sequoyah 2 = 1,148 Mwe), 1 reactor with suspend low-power operating license (Diablo Canyon 1 = 1,084 Mwe), and 4 reactors sh indefinitely (Humboldt Bay = 65 Mwe, Dresden 1 = 207 Mwe, Three Mile Island 1 1,725 Mwe)

[2] Represents rated capability of all operable reactors and accounts for approximate the total U.S. installed electric generating capacity

[3] Stages of reactor construction completed: 2 units = 0%, 25 units = 1-24%, 11 un 25-49%, 17 units = 50-74%, 19 units = 75-99%.

[4] Limited work authorization (LWA) is given by the NRC to allow limited preparatior reactor site prior to the decision on a construction permit. The LWA is not a NRC r but is requested on occasion by the utility

STATUS OF FOREIGN NUCLEAR POWER PLANTS AS OF DECEMBER 31, 1980

179 reactors operable	79,735 Mw
160 reactors under construction	133,605 Mw
27 reactors on order	21,285 Mw
242 reactors firmly planned	234,904 Mw
608 total commitments	469,529 tot

U.S. NUCLEAR MILESTONES IN 1981

Electricity produced from nuclear power plants represented approximately all U.S. electrical output

Nuclear plants produced a record 285-million gross megawatt-hours of el up 8.5 percent from 1980, and the equivalent annual consumption of 28-n households

Nuclear plants accumulated approximately 670 years of operating experier 30% of the worldwide total

During the year, four nuclear units reached commercial operation, 44 nucle projects were delayed and 6 reactors were cancelled

U.S. REACTOR ORDERS OVER THE YEARS

Through 1965	19 units
1966	20
1967	31
1968	16
1969	7
1970	14
1971	21
1972	38
1973	41
1974	26
1975	4
1976	3
1977	4
1978	2
1979	0
1980	0
1981	0

TYPES AND MANUFACTURERS OF U.S. OPERATING REACTORS

	Reactor types:	
PWR	Pressurized Water Reactor	49 units
BWR	Boiling Water Reactor	26
HTGR	High Temperature Gas-cooled Reactor	1
LWBR	Light Water Breeder Reactor	1
GR	Graphite Reactor	1
		78

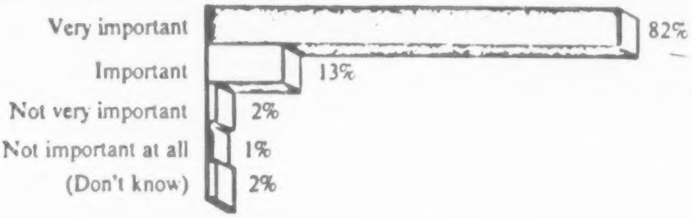
	Reactor manufacturers:	
W	Westinghouse Electric Corporation	33 units
GE	General Electric Company	26
B&W	Babcock & Wilcox Company	9
CE	Combustion Engineering, Inc.	8
GA	General Atomic Company	1
AC	Allis-Chalmers	1

ATTACHMENT 11

Poll Shows Public Demands Government Action on Nuclear Waste

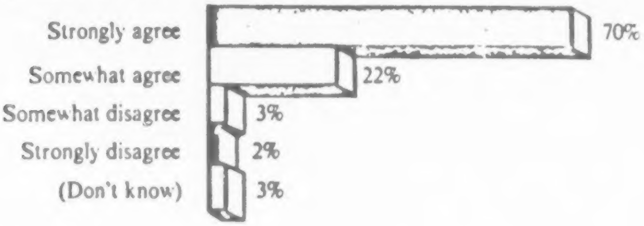
The results of a recent national public opinion survey* show that an overwhelming majority of the American people feel that it is very important for our country to develop permanent sites for the storage of radioactive waste.

How important do you believe it is for our country to develop permanent sites for the storage of radioactive waste?



Furthermore, nine out of ten Americans (92%) agree that it's time for the government to move ahead on a safe method of storing nuclear waste.

Do you strongly agree, somewhat agree, somewhat disagree, or strongly disagree with the following statement: It's about time the government of this country stops procrastinating and starts moving ahead on a safe method of storing nuclear waste.



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* Results of a national survey conducted by Cambridge Reports Inc., Cambridge, Mass. The survey is based on personal, in-home interviews with a representative national sample of 1500 adult Americans, conducted between August 14 and September 9, 1981.

For a copy of the executive summary contact: American Nuclear Energy Council
410 1st Street, S.E.
Washington, D.C. 20003
(202) 484-2670

ATTACHMENT III

REPLY TO:
410 First Street, S.E.
Suite 300
Washington, D.C. 20003

March 3, 1982

Honorable Marilyn L. Bouquard
U. S. House of Representatives
Washington, D.C. 20515

Dear Ms. Bouquard:

This letter is being sent to you on behalf of the undersigned electric utilities and associations representing the systems now operating or constructing nuclear power plants. We serve over 160 million people in this country.

Once again, Congress has the opportunity now to enact urgently needed nuclear waste legislation establishing a comprehensive program to resolve this important national problem. We urge your support of nuclear waste legislation which contains the following essential elements:

- A separate nuclear spent fuel and waste management fund to cover the costs of storage and disposal of commercial spent fuel and high-level waste through reasonable charges to be paid as a cost of service by the electric utility systems;
- A firm time schedule and a disciplined decision-making process at all Governmental levels for the selection and construction of a permanent geologic repository;
- A program for off-site storage of spent nuclear fuel on a temporary or interim basis to assure continued operations of nuclear power plants pending ultimate disposition of spent fuel;
- Federal/state participation procedures to enhance state participation and to resolve state concerns regarding the siting of Federal nuclear waste facilities; and
- An integrated program of research and development to provide timely information needed to validate site suitability and to develop acceptable repository system designs.

The American public is growing increasingly apprehensive over the lack of a definitive national nuclear waste program -- one that can only be established by Congress. In a recent opinion poll (see enclosure), nine out of ten Americans agreed that it is time for the Government to stop procrastinating and move ahead with a program for nuclear waste management. The utilities expect to pay for such a program as a cost of providing service.

Nuclear waste legislation has been pending before Congress over the last several years. Both the House and the Senate passed comprehensive legislation in the second session of the 96th Congress, but failed to resolve their respective differences before adjournment. Nonetheless, a significant political consensus seems to have been achieved.

The respective 1980 Democratic and Republican party platforms have called for aggressive Federal action to resolve this problem. Currently, various legislative proposals are pending before the House and Senate.

Congress must not let the opportunity for passage of nuclear waste legislation slip away again. Congress must act now. Your efforts to promote passage of legislation along the lines described above would be greatly appreciated.

Very truly yours,

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